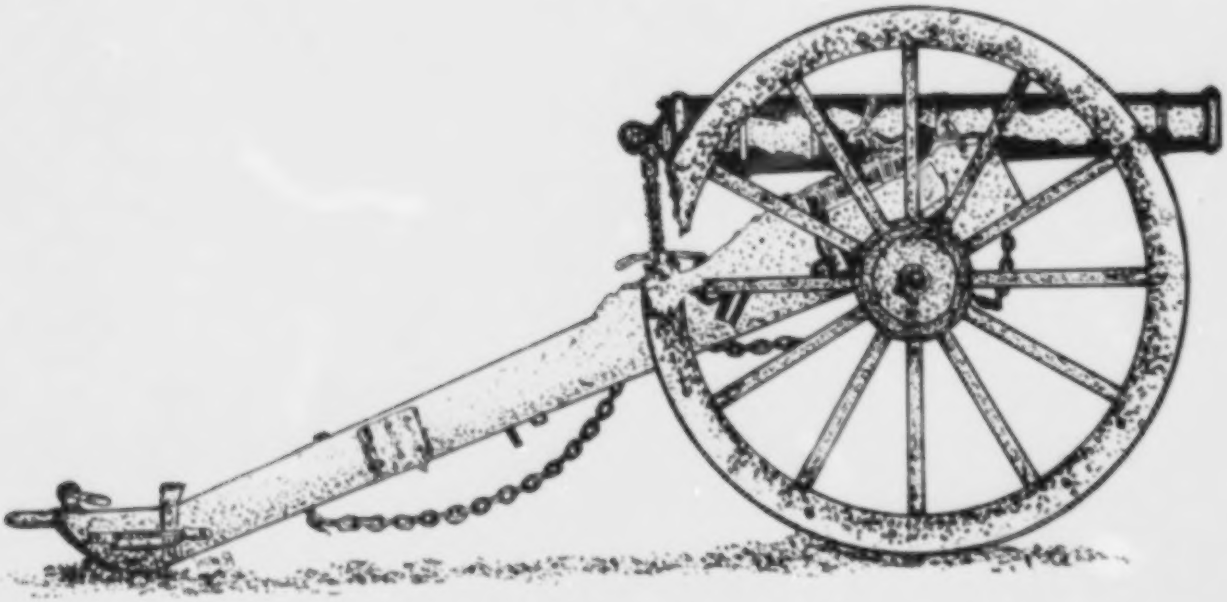
BRITISH SMOOTH-BORE ARTILLERY: A TECHNOLOGICAL STUDY



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DAVID McCONNELL

BRITISH SMOOTH-BORE ARTILLERY: A TECHNOLOGICAL STUDY TO SUPPORT IDENTIFICATION, ACQUISITION, RESTORATION, REPRODUCTION, AND INTERPRETATION OF ARTILLERY AT NATIONAL HISTORIC PARKS IN CANADA

David McConnell

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ABSTRACT

Under its mandate to interpret Canadian history to the public, Environment Canada - Parks initiated an extensive study of the technology of British ordnance *circa* 1710 to the 1860s to aid in the re-creation of period settings at a number of British military sites in Canada. Its purpose is to provide a manual for the reconstruction of pieces of artillery, their carriages and platforms and, as well, to be a source for interpretation of the technology in use at British forts. The study covers the production of ordnance, the history of the development and design of various pieces (guns, mortars, howitzers, carronades), their carriages and platforms, and the development of gunpower, cartridges, fuzes, and projectiles.

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Also, I want to thank my supervisor, Gordon Bennett, who provided me with the necessary stimulus to complete this work and who took the time to criticize it constructively.

PREFACE

As part of its mandate to interpret Canadian history to the public, Environment Canada – Parks administers a great number of military parks and sites, the majority of which originated during the British period of Canadian history. Many of these sites are commemorated with a plaque put up on the recommendation of the Historic Sites and Monuments Board of Canada, but others are being developed and animated. Such development can take the form of static displays, for example, the reconstructed Queen's Battery on Signal Hill in St. John's, Newfoundland, or the gun emplacement in the fort at Coteau-du-Lac, Quebec. However, other operations, such as at the Halifax Citadel, at Fort Wellington in Prescott, Ontario, and at Fort George in Niagara-on-the-Lake, Ontario, are ambitious programs designed to remove the visitor from the modern world to the period of the British garrison. Part of the creation of this verisimilitude has been the reconstruction of British artillery equipments and the re-enactment of period drill and its explanation to park visitors.

Because of the lengthy British presence in British North America and the variety and complexity of British smooth-bore artillery during the period, Environment Canada – Parks initiated a comprehensive study of the technology of British ordnance. Its purpose is to provide a manual to aid in the reconstruction of pieces of artillery, their carriages, and platforms, and as well a source for interpretation of the technology in use at the forts. Initially the stimulus came from Ontario Region, but since the inception of the study both Quebec and Atlantic Regions have been supportive. Indeed, with the exception of Fort Prince of Wales which is really a fur trade post, these three regions administer all of the British military and naval sites of the smooth-bore era.

The scope of the study is extensive. It extends over 150 years, from circa 1710 to the 1860s. The earliest date is somewhat outside the period of British control in British North America, but it must be remembered that pieces of ordnance could have a long life. For example, there are 18-pounder guns still existing on the site of a battery near Digby, Nova Scotia, which were in use during the War of 1812 but which were cast during the reign of King George II. The latter date marks the decade when the first effective system of rifling, breech-loading, and elongated projectiles – the Armstrong system – came into use to replace the ancient smooth-bore, muzzle loading, and round projectile system of ordnance.

In terms of matériel, the study deals with the production of ordnance, the history of development and design of the various pieces – guns, mortars, howitzers, carronades – how they were mounted, the development of projectiles, and the manner of ignition. Not all details of matériel are discussed – merely the most obvious; to attempt more over such a long period of time would be too formidable a task. Nevertheless, it is hoped that both the reconstruction of artillery equipments and their interpretation will be aided by this book.

It was not intended that the study be only of ordnance which has been documented at National Historic Parks and Sites nor only of those weapons presently owned by Parks. Because it is not known for all locations and times what pieces were in British North America, the study was designed to cover all probabilities. However, some equipments which were designed exclusively for the East India Company or for the British army in Africa or India have been ignored.

Parks possesses a great variety of ordnance, however, which has served as illustrative material here. This includes brass field guns (3- and 6-pounders), iron guns of a variety of calibres (from the small swivel guns to the finest smooth bore weapon of the era, the 68-pounder of 95 hundredweight) and of a variety of dates (from the reign of Queen Anne to Queen Victoria's), iron mortars, carronades, and some obscure weapons. (For a list of these weapons see Appendix FFFF.)

A large amount of material has been published about artillery, much of it of a popular nature. A glance at the bibliography of this report will confirm this observation. In particular the work of O.F.G. Hogg, B.P. Hughes, and the continuing series of articles by Adrian Caruana, can be signalled out. But none of these works is as detailed or extensive in its coverage of the subject as the present study attempts to be. It is in large part a technical treatise designed for reference rather than casual reading.

Two iconographic sources which are often referred to in this study but which are readily available should be noted: R.J. Nelson, Gun Carriages: An Aide Memoire to the Military Sciences, 1846 (Ottawa, Museum Restoration Service, 1972) and C.W. Rudyerd, Course of Artillery at the Royal Military Academy as established by His Grace the Duke of Richmond Master General of His Majesty's Ordnance &c. &c. &c., 1793 (Ottawa, Museum Restoration Service, 1970). Because of their accessibility, illustrations from these works have not been reproduced in this study.

Many of the photographs included were taken by me at the Royal Artillery Institution, Woolwich. Notwithstanding the questionable quality of some of the photographs, they have been included for their information value.

Certain usages in this book should be noted. Original spelling in titles and text references has been retained. The spelling "fuze" for the device that ignited a shell rather than "fuse" is the convention adopted by British military writers. Similarly the spelling "cascable" for that part of an artillery piece behind the base ring rather than "cascabel" has been used because it was current with eighteenth and nineteenth century military writers. The term hundredweight (cwt) in the period under study was defined as 112 pounds, and the convention was often used of weighing guns, carriages, etc. in hundredweight, quarters of hundredweight, and pounds. Guns and carronades were usually identified by the weight of the round shot that they fired; thus a 12-pounder gun fired a cast-iron ball that weighed approximately 12 pounds. On the other hand, mortars and howitzers, which fired shells, were usually identified by the diameter of the bore; thus an 8-inch mortar had a bore diameter of 8 inches. There were certain exceptions — shell-guns, which did not fire solid shot, were identified by their bore diameter and the Millar field howitzers were identified with the guns of which they had the same bore diameter (e.g., a 12-pounder howitzer had the bore diameter of a 12-pounder gun). The term equipment is sometimes used to describe an artillery piece, its carriage, and accoutrements as a unit.

THE MANUFACTURING OF ORDNANCE

During the two centuries before 1700, the beginning of the period under study, gunfounders had developed two materials that had the requisite qualities for the manufacture of ordnance — hardness, tenacity, and elasticity.

In 1858, at the culmination of the smooth-bore era, an artillery officer explained the need for these qualities:

> The material should be hard, so as not to yield too easily to the action of the ball when passing out of the bore; tenacious, so as to resist the explosive power of the Gunpowder and not to burst; and lastly, elastic, so that the particles of the material of which the Gun is composed should, after the vibration caused by the discharge, return to their original position.[1]

Artillerists found that cast iron and brass or gun-metal met these requirements. (Strictly speaking, the latter composition was bronze, but contemporaries referred to it as brass or gun-metal and to the ordnance cast therefrom as brass ordnance.)

Brass or gun-metal was an alloy of copper and tin, usually in the proportion of 10 parts tin to 90 parts copper for guns or howitzers and 12 parts tin to 88 parts copper for mortars.[2] In their pure form both components were inadequate to be cast into ordnance. Copper, a very tenacious, ductile, and malleable metal, with a relatively high fusing point (1083.0°C), was much too soft to withstand the passage of a shot down the bore. Tin, less ductile than copper but malleable and even softer, possessed an added disadvantage of melting at a relatively low temperature (231.9°C). It had been known for centuries, however, that an admixture of tin to copper served to harden the latter metal, although too much tin made the resulting mixture brittle and thus liable to fracture. Copper and tin in the proper proportions produced an alloy harder than either of its components, quite tenacious, and with a fusing point somewhat lower than that of copper but considerably higher than that of tin. Its advantage in gunfounding was its strength; its disadvantage was its tendency to heat up quickly, become soft and thus susceptible to damage in the bore. Brass ordnance could not sustain rapid firing over a long period of time.[3]

While most authorities included only copper and tin in the composition of brass or gun-metal, some indicated that a small proportion of true brass (i.e., an alloy of copper and zinc) was also added. The anonymous writer of an eighteenth century notebook remarked:

> Some Founders recommend a small mixture of Brass from a Notion that it promotes the union of the Tin with the Copper, but this opinion does not appear to be founded on sufficient grounds, and it should if used at all be added very sparingly, as the piece might be endangered from its brittleness when violently heated by repeated firing.[4]

Analysis of the metal of a number of pieces of British brass ordnance of various dates at the Tower of London has revealed that not only was zinc present in small proportions but lead as well. Various other elements were also identified in minor to trace quantities. Guns cast toward the end of the smooth-bore era were closer to being bronze, that is, entirely of copper and tin.[5]

Type		Date	Copper %	Tin %	Zinc %	Lead %
2 pdr. gun	ca.	1700	79.5	11.3	0.50	3.55
Mortar		1726	89.1	6.8	0.30	0.35
24 pdr. gun		1743	90.8	2.25	0.10	0.75
Howitzer		1798	86.0	8.75	0.15	0.80
Howitzer		1810	87.1	6.65	0.15	1.00
6 pdr. gun		1850	87.5	8.5	0.05	0.50
9 pdr. R.M.L.		1870	88.7	8.1	0.05	0.40

Iron, the other material utilized to make ordnance, rarely exists in a pure form. In a manufactured state it contains a proportion of another substance, usually carbon. Wrought iron, the most pure, is relatively soft, and very tenacious, but it can only be fused at a very high tempeature. Ordnance had been made of wrought iron, but, because of the manner in which the iron was produced, only comparatively small weapons could be manufactured. Cast iron, which contained more carbon, about five per cent, was much harder, more brittle, and fused at a lower temperature. Produced by smelting iron ores in a blast furnace which burned charcoal or, later, coke, the molten iron could be cast directly as ordnance or alternately as pigs. The latter could be resmelted in a reverberatory furnace to be cast into artillery pieces. Considerably harder than brass ordnance but not as strong, cast iron pieces were heavier with a greater thickness of metal than their brass equivalents. They were less prone to injury in their bores, did not heat as quickly or melt at so low a temperature, and they were considerably cheaper to produce. Slowly cast iron guns superseded brass in all branches of artillery except in the field where lightness was of paramount importance.[6]

There is no detailed eighteenth century account of gunfounding in Britain until the 1770s. Most descriptions are based on continental manuscripts or books and, while undoubtedly correct in their broad outlines, do not provide detailed pictures of what was happening in British foundries. Recently a series of 50 drawings, executed probably by Jan Verbruggen (1712-81) or possibly by his son, Pieter (1735-86), master founders at the Royal Brass Foundry, Woolwich (1770-86), have been published, providing a graphic account of the process as it was practiced there in the late 1770s and early 1780s.[7] Supplementing these are two manuscripts in the library of the Royal Artillery Institution, Woolwich, written by Isaac Landmann, a teacher at the Royal Military Academy from 1777 to 1815.[8] One, written in 1793, seems to be daily notes of activities in a brass foundry, undoubtedly at Woolwich. The other, bearing the date 1795, appears to be the manuscript for a book based on the notes of the first volume, although there is no evidence that it was ever published.[9] Unfortunately no similar detailed records of iron gunfounding in eighteenth-century Britain have been found, but it is fair to say that the processes were similar.

In order to cast a piece of ordnance, either of iron or of brass, an exact model of it was built up of loam and clay on a wooden spindle bound with rope or twine. Once this had been dried it was coated with carbon or wax, and the mould, which produced the negative image, was shaped over it similarly in layers of loam and clay. After being dried, it was encased in reinforcing iron staves and hoops, the model was removed, and it was buried upright in a pit before the smelting furnace. When the bath of metal in the hearth was sufficiently fused, workmen tapped the furnace allowing the molten metal to flow into the mould. A feeding-head or dead-head was cast on top of the piece either in a separate mould attached to the barrel mould or in an extension of it. This provided for extra pressure on the metal hardening in the barrel proper and allowed for filling up the shrinking volume of metal as it cooled.

Once cool, the casting was taken from the pit, the mould broken off, the barrel deburred and smoothed, and the dead-head cut off.

Originally, guns, mortars, and howitzers, either of iron or of brass, were cast on a core, built up of iron wire and clay over an iron spindle to the dimensions of the bore. When the casting had cooled, the core was removed and the rough hole left was reamed out to smooth it and to bring it to the exact dimensions of the bore. Quite often, unfortunately, the bore was not true because either the core had shifted under the pressure of the molten metal or it had been warped by the heat. An obvious solution to this problem was to cast the gun solid and then to drill out the bore.

While the solution may have been obvious in theory, the implementation of it in practice necessitated improvements in drilling technology. In 1715, Johann Maritz of Burgdorf, Switzerland, invented a new cannon-boring mill that incorporated two revolutionary innovations in technique. Firstly, the piece, rather than the drill, was rotated, and the drill was fed into it. Secondly, the piece and the boring machine were placed horizontally on a solid stone foundation, not vertically as before.[10]

Maritz's machine had a number of advantages over the older vertical boring devices. Because the piece rotated rather than the drill, it was easier to make the bore straight and concentric with the axis of the piece. The horizontal position allowed the massive stone foundation to be an integral part of the machine, far less flexible than the timber jig which in the vertical machine held and lowered the piece. Also, it was far easier to control the light iron drill than the heavy frame and piece of artillery of the earlier machine. The new technique also allowed for machining simultaneously with boring. Lastly it was much easier to load a piece of artillery into a horizontal than a vertical mill.[11]

Despite the success of the Maritz technology on the continent, some 50 years were to pass before it reached England. The delay may have been due to the reluctance of the French, who first adopted the new technique in their foundries, to allow its export but it was also attributable to the conservatism of English founders, particularly of Andrew Schalch, master founder at the Royal Brass Foundry, Woolwich, from 1717 to 1770.

The Royal Brass Foundry was established in 1716. The Board of Ordnance had been thinking of such an institution for a number of years with the hope of standardizing land ordnance, of providing specifications for contractors, and of ascertaining costs. Two events — the disaster of 10 May 1716 at Mathew Bagley's foundry at Moorfields in which a casting blew up killing Bagley and a number of onlookers and the discovery that the royal stores of brass land ordnance contained only two 12 pounders — spurred on the Board to make the decision on 19 June 1716 to set up the foundry.

Andrew Schalch, who had been trained at Douai in Flanders, was the first master founder at Woolwich. During his tenure of 43 years he did little to keep up with European technology. By the end of the Seven Years' War the foundry was a shambles and the Board of Ordnance was looking to replace its master founder. The Board opened negotiations with Jan Verbruggen, master founder of the Heavy Ordnace Foundry at The Hague, but these initial negotiations in 1763 fell through, and it was not until 1770 that the Board secured the services not only of Jan but also of his son Pieter.

The elder Verbruggen had been appointed master founder at Enkhuizen, West Friesland, in 1746 and had accepted the same position at the National Heavy Ordnance Foundry at The Hague in 1755. With the aid of Johann Jacob Spiegler who knew of the Maritz machine at Douai, over the next three years Verbruggen designed and built a new horizontal boring machine, the knowledge of which he brought to England in 1770. The arrival of the two Verbruggens at Woolwich that year brought energy and experience in European technology to replace Schalch's lethargy and incompetence. They had to rehabilitate the foundry, rebuilding the old furnaces and adding a new one. They disposed of Schalch's ancient vertical boring mill and built two new horizontal boring machines, one for cannons and one for mortars. (Later in 1776 they added a third.) By 1774 the newly reorganized Royal Brass Foundry at Woolwich was in production. So satisfied was the Board of Ordnance that henceforth all brass ordnance was to be cast at Woolwich, putting an end to the system whereby Schalch had contracted out some of the work.[12]

In 1774, shortly after the Verbruggens had introduced the Maritz technology to England, John Wilkinson, an ironmaster, patented a horizontal boring machine for iron cannon which seems to have been essentially the same as the Verbruggens'. Whence Wilkinson obtained his knowledge is not known, but he could have seen the Maritz system in France or Holland. At this time, a certain Anthony Bacon, who was probably associated with or working for Wilkinson, submitted proposals to the Board of Ordnance to manufacture solid bored-out cannon. The Board, which had just experienced a great number of failures of guns cast by the Carron Company in Scotland, was receptive and called in the Verbruggens to report on Bacon's castings. The Board of Ordnance was so impressed with their findings that on 15 August 1776 it stipulated that henceforth only guns cast solid and bored out would be accepted into service. Wilkinson's invention was so successful that other ironfounders soon copied it despite his patent. By the late 1770s all ordnance in England, brass and iron, was being cast solid and bored out.[13]

The technology which the Verbruggens introduced into the Royal Brass Foundry in the 1770s did not change in essentials for over two generations, not until the 1840s, when new machinery was installed, and the mid-1850s, when the moulding techniques were revised. By a study, therefore, of the Verbruggen drawings, of Isaac Landmann's commentary, and of subsequent briefer descriptions it is possible to construct a detailed picture of the process of brass gun manufacture as it was carried out in the Royal Brass Foundry from the 1770s to the 1840s.

The first stage of the process was to create an exact model of the gun, mortar, or howitzer that was to be cast. This was built up upon a tapered wooden spindle, from eight to 12 feet in length and about two inches less than the model in diameter. A sloping neck was cut into it about a foot from its thicker end and two holes were drilled through this head to hold two cross bars by which the spindle was rotated. As the years passed, the shape of the spindle may have become more formalized. A drawing in a cadet notebook of 1849 gave very detailed dimensions for the spindle of a 24-pounder howitzer.[14]

The spindle was then set upon a wooden turning frame and covered with grease or soap to aid in its eventual removal from the mould. Beginning at the breech end, workmen began winding a plaited straw rope around it. On smaller pieces the rope was used only at the breech and muzzle ends while cord or yarn was wound around the middle section. Landmann depicted the turning frame as separate, but most other works showed it sitting atop a brick firebox in which a fire would be lit to dry the mould during the next stage.[15]

Over top of the rope or cord armature, workmen began to plaster on a composition to complete the model. This was a combination of clay, sand, horsedung, and water, well beaten and mixed to give it a smooth and homogeneous consistency. Layers were put on by hand, each dried over a fire, until somewhat more than the required dimensions were reached. Then a wooden stickle board or pattern of the profile of the piece being modeled (by the 1790s edged in iron), was held against the model to smooth and shape it as it was turned on the frame. Finally the model was coated with wax or a solution of wood ashes in water to prevent it from adhering to the mould.

With the aid of a trunnion gauge that ensured that the trunnions were level and at right angles to the axis of the model, wooden replicas of the trunnions, well greased, were attached by long iron skewers or nails. Finally wax models of the dolphins (if required), of the vent shell, and of the arms of the monarch and of the Master-General of the Ordnance were made in permanent moulds and attached in their proper place by iron skewers. In the nineteenth century the regulations called for the ornamentation to be engraved, thus doing away with the wax models of the coats of arms. Also, the models of the vent pan (much simpler than a shell) and of the front sight were made of lead. The dolphin models remained of wax.

Once the model was dry, the mould, which was the negative image, was built up on top of it. The initial two or three layers of composition, put on by hand, were a combination of finely pulverized refractory clay and silicon sand, with perhaps a small amount of cow's hair, well mixed in water. Since fire drying would melt the wax, each layer was allowed to dry in the air. Then a coarser mixture of clay, sand, and larger amounts of cow's hair was plastered on by hand, coatings of it alternating with coverings of tow (flax or hemp) which aided one layer adhering to the next. Before they became buried in the composition, the iron skewers holding on the ornaments and dolphins were carefuly removed. When the mould had reached the required thickness, its final shape was determined by the application of a pattern board. After the final coating was dried over the fire, iron staves, which matched the shape given to the mould by the pattern board, were bound tightly around it by iron hoops. It was finished by a final application of fine mould composition and then dried over a fire.

In preparation for the removal of the model, the completed mould was lifted from the turning frame and placed upon a wooden cradle. A workman struck the narrower end of the spindle, which was conical and well greased, with a wooden mallet, while other workmen steadied the opposite end of the mould and carefully removed the loosened spindle. The rope was then wound out of the cavity and set aside for future use. The trunnion models were either pulled out or shoved into the cavity and removed. To calcine the clay of the model that still remained, a fire was burned inside it and the debris broken or swept out. The fire melted whatever wax remained of the dolphin and ornament models. Later when lead replaced wax to model the vent pan and front sight, these models had to be picked out by hand. Workmen then inspected the interior for any defects or flaws, and repaired any they found with a trowel and model composition. A coat of a lye mixture was spread over the interior surface to prevent the molten metal of the casting adhering to the walls of the mould. The mould was then taken to the casting pit to be annealed.[16]

The Verbruggen drawings indicate that the dead head and barrel moulds, except in the case of large mortars, were made as a unit. Landmann and subsequent authorities say that the dead head mould was constructed separately and then attached to the main mould in the casting pit.[17] It was made in exactly the same way as the main mould, of dimensions to fit onto the latter. A hole was drilled into it near its top into which a clay pipe or sprue was introduced, through which the molten metal would flow into the mould. Bound with iron staves and hoops the dead head model was taken to the casting pit to be attached to the main mould by wires through holes in the ends of the staves.

In the casting pit the mould was supported upright on a low foundation of bricks with intervals between them. A charcoal fire was lit beneath the mould and old hop poles burned within. The fire was kept going for two or three hours until the interior of the mould was red hot, the clay on the verge of vitrification. Then it was put out, the mould was covered with an iron lid, and allowed to cool. This process of annealing hardened and toughened the clay to resist the molten metal of the casting.

At this point the main mould was ready to be attached to the cascable mould which had been made separately using similar methods. This model was built up upon a wooden disk, its diameter depending on the size of the piece to be cast, pierced through the centre by a wooden spindle. Modeling composition was layered onto the disk and straw rope was wound around the spindle followed by coatings of composition. When the appropriate size was reached the proper shape was achieved by using a stickle board or pattern. Once it had dried it was coated with wax or a solution of wood ashes. The mould was built up over it with alternating layers of mould composition and tow until the correct size was realized whereupon it was dried over a charcoal fire. Since the cascable mould had to bear the entire weight of the mould and metal, the Verbruggens placed it in a metal container which it was made to fit exactly. Landmann indicated that the container was used only with heavy pieces. The cascable moulds of lighter pieces were strengthened by being encircled with two metal straps.[18] At this stage a collar was turned on the cascable mould to ensure its exact fit into the main mould. The model was removed and the mould was annealed by burning charcoal under it.

The open breech end of a small mortar was closed slightly differently because its trunnions, unlike those of a gun or howitzer, were located at its extremity. The models of the trunnions were removed in the usual way. A plug of loam was fashioned to the required size and its interior surface moulded against a long model of the trunnions inserted into the trunnion holes. Incorporated into the plug was the mould of the protrusion to fit into the chuck of the boring mill.[19]

According to the Verbruggens the mould of a large mortar could not be built up on a horizontal model. Rather it was constructed much in the manner of a bell mould, around a vertical spindle. An iron tripod, from which an iron rod ran to a wooden beam above, was set atop a brick firebox. A stickle-board, or template, rotating through 360 degrees, by which the model was shaped, was attached to the iron rod.

A brick armature was built up around the tripod in the general shape of the mortar. Onto this workmen applied layers of clay to build up the model, which was finally shaped by the application of the stickle-board. Coincident with the application of the clay, a fire was lit in the firebox to ensure a gradual drying of the model. The breech section was produced separately and attached, the metal rod being removed beforehand. Finally a wax coating was applied and the wax models of whatever ornaments were called for were attached with iron skewers.

When the model was dry, the mould was built up in the usual way by smoothing on layers of composition. After a template, attached to the overhead beam, was used to give the mould its final shape, the iron reinforcing loops and staves were attached. The massive mould was then lifted by block and tackle off the firebox and placed on a wooden cradle where the brick armature and clay model were removed. After inspection and repair, if necessary, the interior surface was brushed with a solution of ash to prevent the molten metal penetrating the mould. After it was well baked it was ready to be taken to the casting pit, where the dead-head mould would be attached.[20]

Once the cascable mould of a gun or howitzer was ready it was taken to the casting pit, where the main mould was lifted up, the brick support and ashes cleaned out, and the ground carefully levelled. The cascable mould was lowered into its proper position in the pit. Into it a disk of cloth, the edge of which was pierced by a number of small rings, was placed. This cloth served as holder for a small candle, by whose light the workmen could observe the joining of the cascable and main moulds, and as a depository for any dirt or debris which might fall into the mould. It was eventually removed by hauling it up on a long string that was threaded through the rings and extended upwards through the barrel mould.

The main mould, with the sprue opening facing inwards, was lowered carefully onto the cascable mould. The candle was snuffed out and all the openings were closed to prevent debris from entering. The joint of cascable and main mould was smeared with composition to ensure as close a fit as possible. Finally it was ascertained that the mould was perfectly vertical.

From an adjoining pit workmen lifted baskets of damp earth, spread it thinly between the moulds (more than one piece was usually cast), and firmly compacted it by tamping with iron or bronze weights. The trunnion holes were closed with firebrick when the level of the earth reached them. The filling and compacting continued until the sprue holes were reached. The work was completed as quickly as possible, as many workmen as were available or could fit into the pit being employed. They tamped the earth until it had the solidity of stone.

A channel of loam, or later of firebricks, which led from the furnace door and passed by the various sprues, was built into the surface and was so constructed that it sloped away from the furnaces.[21] At its end a pit was dug to hold any excess metal. Iron plates would be inserted into the channel at intervals so that the moulds could be filled consecutively, not all at once. The channel was fired with charcoal to anneal it.

While the pit was being readied the furnace in which the charge of metal was to be melted was lit. The furnace was the reverberatory type, that is the firebox, in which cordwood was burned, was separated from the furnace proper where the metal was melted. The flames, passing through the firehole, played over the metal and heated the roof of the furnace to a white heat, thus melting the metal by both convection and radiation.

The charge of metal consisted of old used-up guns, captured pieces, metal filings, deadheads, and other scraps as well as such amounts of pure copper and tin as would be sufficient to create a gun-metal of the proper proportions. The founder carefully weighed the metal to equal the weight of the pieces to be cast and assayed its quality, either by eye or by immersing samples in nitric acid to ascertain the proportions of copper and tin. Pure ingots of the latter metals would be added toward the end of the smelt to adjust the proportions if necessary.

It was important that the furnace be heated gradually to ensure as little damage as possible to its walls and especially that the floor be well heated before the charge was introduced and melted. Sometimes large old pieces were put in beforehand, but they were elevated above the furnace floor by bricks to allow the flames to play around and under them, heating the floor of the furnace before the metal fused. As the metal melted more and more of the charge was added to the molten bath which was kept well stirred by wooden poles. Periodically the dross on the surface was skimmed off with a large wooden rake. Toward the end of the smelt, the founder, if he thought it necessary, threw in the pure ingots of copper and tin. Workmen stirred and skimmed the bath once more and the furnace was ready to be tapped.

While the metal was being brought to the proper temperature, the founder was coordinating activities outside the furnace so that all would be completed precisely when the furnace was ready to be tapped. The charcoal fires that annealed the channel were not extinguished until just before the tapping so that the channel would be hot when the metal flowed through it. It was swept out and the metal sluice gates which controlled the flow of metal were inserted. The covers were removed from the moulds and the cloths containing the candles and any debris that had fallen in were taken out in the manner previously described. According to Landmann, the bottom of the moulds were cleaned out by a ball of wax on a long pole.[22] The sprue openings were uncovered and iron plugs of a shape to fit them on the end of iron rods were inserted into the sprue holes of the first moulds to be filled.[23]

The furnace now could be tapped. Using the crook or lancet, a long iron pole curved into a semi-circle at one end and suspended by chains so that it could swing freely, a workman drove the iron plug of the tapping hole into the middle of the furnace, allowing the molten metal to run out into the channel. In order that as little dross as possible would flow into the moulds, the level in the channel was allowed to rise above the level of the sprue openings before the stoppers were removed, thus allowing only the pure metal to enter. Once the moulds in the first section were filled (this might be two or four depending on their size), the sluice gate was removed and the metal allowed to flow into the next section where the same procedures were followed. When all the moulds had been filled the last sluice gate was pulled up and the excess metal allowed to flow into the pit to be saved for future use. Once the furnace was empty, the iron plug was retrieved the fire was put out, and the doors and chimneys were closed.

When the moulds had cooled for a day, workmen began the dirty, hot, and uncomfortable job of digging them out. This was done as quickly as possible, for slow cooling made the metal brittle. When the earth level had been reduced sufficiently, each mould was broken free by block and tackle, usually leaving the cascable mould behind in the fill. Once out of the pit the hoops and staves were removed and the mould broken off with a sledge hammer. Then a hammer and scraper were used to remove whatever crust had formed on the surface of the piece. The dead head was sawn off by hand and a chisel and file used to remove whatever inequalities remained on the cross section.[24] The piece was ready to be taken to the machine shop to be bored.

In the machine shop the axis of the piece was determined by finding the centre point on the face of muzzle and on the protrusion behind the button. At this point a hole was drilled into the muzzle. The protrusion at the other end was chipped and filed into a square which would fit into the chuck of the rotating device. This done, the piece was mounted in the lathe; one end rested in the chuck, and the muzzle was supported by a steel centre inserted into the hole and mounted on top of the boring table.

The muzzle was to turn in a support, called a steady-rest, at the end of the boring table. In order that it would run true the piece was rotated and a collar of the same size as the hardened steel bearing of the steady-rest was cut round the muzzle concentric with the centre hole. The steel centre was removed and the muzzle clamped into the steady-rest. The centre hole was enlarged to take the first of the three or more drills, each of an increased diameter, which would be used. The cutting edge of the drill was at the end of a long rectangular shank which was securely clamped between two exactly parallel metal guides. The drill and the axis of the piece had been lined up with the aid of a series of plumb bobs hanging from the ceiling above the lathe and boring table. As the piece was turned by horse power, the drill was gradually fed into it by a rack and pinion device at the rear of the drill shank.

While the boring was progressing, the surface of the piece was being smoothed by a chisel as much as the ornamentation would allow. Later, when the ornamentation was engraved most of the surface of the piece could be finished at this stage. Areas that could not be reached were finished later by hand with chisels and files. The trunnions were also brought to their proper size and shape by hand. Finally the vent was drilled and the piece was ready to be proofed.

Before discussing proofing, I want to describe a machining process was carried out after the piece had been tested, namely bouching.[25] A bouch was a threaded plug, usually of copper, with the vent hole drilled along its axis, that was screwed into a piece at the vent. Bouching was adopted to combat the enlargement of the vent as a piece was fired. Copper was used because it did not melt at as low a temperature as gun-metal nor corrode as readily as cast iron.

Brass guns were issued bouched, but it is not known when the practice began.

Landmann described the process in 1793, but there are no references before this.[26] Possibly the practice was first adopted sometime in the 1780s.

The evidence concerning the bouching of cast iron guns is more abundant. The vents of the iron guns at the sieges of Badajoz and San Sebastian during the Peninsular campaign in 1812 and 1813 had enlarged badly. In consequence the Royal Artillery carried out experiments at Woolwich in the autumn of 1813 testing common, wrought iron, and copper vents. Copper withstood the firing best, although wrought iron also resisted well. It was decided, therefore, to bouch guns with copper when their vents had become enlarged from .2 to .25 of an inch. In 1855 it was ordered that all iron guns (except 6- and 9-pounders which by then were only used to fire salutes) were to be bouched before issue.[27]

From 1844 to 1855 wought iron bouches were used. It was believed that a "galvanic" action was set up between the copper bouch and the iron gun which caused their corrosion. In 1855 experiments proved that this was not true and the use of copper bouches was resumed.[28]

The process as described by Landmann and later manuals remained essentially the same although the tools became more sophisticated. The vent hole was drilled out into the bore, first with a narrow and then with a larger set of drills. The latter drilling did not penetrate into the bore but stopped where the thread was to end. The remainder of the hole was finished as a cone. The hole was then tapped down to the beginning of the cone, burrs were removed, and the hole was cleaned with tow. Next the copper bouch, well oiled, was screwed in by a hand lever or wrench.

The bouch was a threaded cylinder of pure copper, with a vent drilled lengthways along its axis, one end squared to receive the wrench and the other slightly conical. This conical end ensured a tight fit into the bore of the gun. After the bouch had been screwed home an impression of the end of the bore was taken to ensure that the fit was proper and that no gap existed between the bouch and the bore. Then the projecting end was cut off with a long cutter especially designed for the purpose, care being taken that the two surfaces were flush. Then that part of the bouch above the surface of the gun was sawn off and by the use of a chisel and hammer made flush with the surface. Then the vent hole was opened and the vent reamed and gauged. A final impression was taken inside the piece and if that was satisfactory the operation was finished.[29]

Landmann's description in 1793 differed in some details from the above, being less refined. Landmann made no mention of the conical end, either of the bouch or of the hole it was to fit. The accompanying drawing in his manuscript showed that the thread extended the length of the bouch and hole. The projecting end of the bouch was cut off by the final drilling bit inserted into the bore and turned by hand.[30] It is not known when the cone bouch was developed; perhaps it arose out of the series of experiments at Woolwich during the autumn of 1813.

The process of manufacture of brass ordnance in the Royal Brass Foundry, which has just been described, remained essentially constant until the 1840s. The machinery that the Verbruggens installed remained in use until 1842, when the Inspector of Artillery, Colonel Dundas, inaugurated a series of changes by which, in the opinion of one expert, "...the manufacture of brass guns...was brought up to as great a degree of perfection as may be considered attainable in the present state of the art."[31] The old horsepowered boring mills were done away with, a steam engine was introduced, new boring machinery brought in, and new machinery designed and built to perform those tasks originally done by hand with file and chisel. The same jobs had to be done but they were done more efficiently and more accurately:

> If this Department, as it stood in 1841, with its rude boring mills turned by horses, and with all the finishing work performed by the hand chisel and file of the workman, were

> placed side by side with the Department in 1851, furnished as it was with steam power, with numerous lathes, and with self-acting machines for boring, turning, and finishing the guns, the value of the labour and energy which has been expended thereon, would be sufficiently apparent.[32]

Shortly after 1855, when Colonel F. Eardley Wilmot had been appointed superintendent of the Royal Brass Foundry, a new method of creating the moulds for brass guns was introduced. Instead of being destroyed each time a mould was made, the model, which was cast in iron, could be reused. The model of one-half of the piece, convex surface uppermost, was attached to a specially designed cast iron table. It was carefully oiled and sprinkled with dry sand to prevent adhesion to the mould. A cast iron jacket or gun box was carefully placed over the model and the interval between them rammed with the mould composition, a mixture of two parts loam and one part sand. When the space was completely filled, the model was withdrawn by a device which lowered it through the section of the table on which it rested. The interior surface of the mould was washed with a mixture of tan-ash and water to prevent the molten metal penetrating the mould wall during casting. A large number of holes in the metal jacket allowed the mould to be ventilated by driving a pricker almost through its walls. These holes permitted gases to escape when the metal was poured in. Then the mould, and its mirror image, were taken to the stove (i.e. a room with a grate in it) for drying. After 10 or 12 hours the two half moulds were taken to the casting pit, lowered in, and bolted together. In the meantime, the gun metal had been melted in a reverberatory furnace. When the bath of metal had achieved the proper temperature, the furnace was tapped to release the molten metal. It flowed into the mould along a wrought iron channel covered with 3/4-inch of loam to protect the iron. Apparently the mould was no longer buried but propped up in some manner. After cooling for about an hour in the pit, the moulds were taken out and, when properly cool, the castings were finished and machined in the manner already described.[33]

The discussion to this point has been mainly about the manufacture of brass ordnance, about which we have considerably more information than about the manufacture of iron. Until late in the 1850s all iron pieces were cast by private manufacturers from whom no documents comparable to the Verbruggen drawings or Landmann's descriptions have come down to us. The two processes were similar.

Originally all ordnance, whether brass or iron, was cast in clay or loam moulds, in the manner already described. Another method, casting in sand moulds, was adopted for iron weapons. Hughes in his study of smooth-bore artillery claims that sand moulds were being used by 1750, but he gives no source.[34] There is no detailed description of the process in England until well into the nineteenth century. The most complete was given in 1809 by Louis de Toussard in The American Artillerist's Companion.[35] The author was a French artillerist in the American service, but he seems to have been quite familiar with British authorities. His description of iron gun casting matched closely with later descriptions in British manuals. Little change seems to have occurred in the process during the first 60 years of the nineteenth century and quite possibly during the years before.

Whereas the model was destroyed when the clay or loam method of the Verbruggens was used, the model was retained for reuse when sand casting as described by de Toussard was employed. The model was an exact replica of the piece, made of hard wood, iron, or brass. It was divided into a number of hollow pieces – cascable, two reinforces, chase, muzzle, and deadhead. A cast iron jacket or flask which would contain the model corresponded to each of these parts. Except for the two cascable flasks, all the others were in halves joined longitudinally by pins and keys (later by nuts and bolts). Flanges on the ends of each flask allowed it to be joined to the next flask. The mould was built up by ramming sand in the interval between the flask and the model.

The sand had to have certain characteristics. It must not melt during the baking of the model or the pouring of the metal. It must not have too much clay mixed with it or it would contract too much during drying. Its grains had to be rough and angular in order that it would hold together. A sand of quartz, angular, rather coarse, and very refractory, was prescribed. In order to give the composition consistency it was moistened with water in which clay was dissolved and well mixed.

Each model, which was coated with a carbon solution, was centred vertically inside its flask and sand was rammed down between it and the flask, care being taken that only a small amount of sand was rammed at one time. When one section was finished its upper surface was sprinkled with powdered charcoal to prevent its adhering to the next section. Then the next model was lowered onto the completed model and mould, the two models being joined by rabbets. The corresponding flask was then put into place and connected, and more sand was rammed here. This process was repeated until the deadhead was finished. The trunnion moulds were attached to the main mould by screws from the inside. The sand was rammed home from the side and metal covers were fixed over the flask openings. The screws were taken out before the main model was removed.

When the mould was completed, the flasks were disassembled and set upon the ground, their large ends uppermost. The hollow models were disengaged from the sand and lifted out to be reused. The trunnion models, their attaching screws having been previously removed, were pulled from their positions. The flasks containing the moulds were then taken to the stove, a brick lined room with a large grate, in which they were dried for about fifteen hours. The interiors of the moulds were then brushed with a coating of carbon and clayed water to prevent the molten metal adhering to the surface of the mould. Following this the flasks were taken to the casting pit where they were resassembled. The process of casting and machining was similar to the process for brass ordnance already described.[36]

Before a piece of ordnance was accepted into service it was necessary to ascertain that it met the specifications set forth by the Board of Ordnance and that it was safe to fire. It was submitted to proof by the Ordnance at Woolwich. A parliamentary commission in 1783 neatly summarized the process:

> Every gun first undergoes an examination, and then a proof [i.e. by being fired]. The examination is performed with Instruments calculated to discover errors in the forms and position of the bore, and to ascertain whether the construction is agreeable in every respect, to the mould sent as a pattern to the Gun-Founder; then by forcing water into the bore; and lastly by an inspection of the inward surfaces, effected by throwing into it a quantity of light, by means of a mirror, which frequently discovers concealed defects that escape every other examination and proof.[37]

No descriptions of proofing before 1750 have been found, but there are tables of proof powder charges from the 1720s and perhaps before.[38] Accounts after 1750 agree, more or less, in their general outlines.

The piece of ordnance, whether brass or iron, gun, howitzer, or mortar (or carronade after 1779), was first inspected by eye and by instruments to detect any imperfections. Its length was measured and the thickness of metal ascertained. The bore had to be of the proper diameter and its axis coincident with the axis of the piece. The trunnions must be level, of the correct diameter, and in their proper position. The vent had to be of the proper diameter and correctly bored. Small variations were allowed, but discrepancies beyond these resulted in the piece's rejection.

The interior of the bore was next inspected. A searcher was used to detect holes or honeycombs in the bore. It consisted of an iron socket, with four to eight branches bent outward at their ends into sharp points, connected to a pole of from eight to 12 feet. The searcher was inserted into the bore of the gun and twisted around as it was slowly withdrawn. The branches of the socket were sprung outwards and became caught in any hole that was in the surface of the bore. If a hole was discovered, a chalk mark was placed on the handle of the searcher and also at the hole's position on the exterior surface of the gun. Then a second searcher with only one point, on which a mixture of wax and tallow was stuck, was inserted to discover the hole and to take an impression of it. If the hole was 1/4-inch deep or of a considerable length the piece was rejected. This regulation was refined by the 1790s: a hole of 0.2 inch in the charging cylinder or 0.25 inch in the chase caused the rejection of the piece.[39]

One other instrument, the reliever, should be noted. It was a flat ring attached by a socket at right angles to a pole. The ring was put over the searcher pole and thrust into the gun to release the seacher if it became stuck.

In the 1770s General Thomas Desaguliers invented a more sophisticated and complex instrument to detect imperfections in the bore.

> This instrument, grounded on the truest mechanical principles, is no sooner introduced into the hollow cylinder of the gun, that it discovers its defects, and more particularly that of the piece not being truely bored, which is a very important one...[40]

This device, or one based on its principle, was still in use almost a century later (See Appendix B for a detailed description of its operation).

When a piece had been successfully proofed by instrument, it was taken to the proofing butts where it was fired twice with a predetermined charge of powder, two junk wads, and ball (carronades were proofed with only one wad) [see Appendix C for proof charges]. After each firing it was carefully inspected and searched as before to detect any holes or cracks which had appeared. The guns were laid on the ground supported by a billet of wood to raise their muzzles slightly and fired into a wooden butt. Mortars and howitzers were fired at an elevation of 70 degrees out into the Thames.

If the piece passed this trial, it then had to undergo the water proof. John Muller had doubts about its efficacy.

> Sometimes water is forced into them, but this proof is insufficient; it has been found, that though the water penetrated through the piece in several places, yet they were very good and serviceable.[41]

Smith does not mention this proof in his An Universal Military Dictionary in 1779, but it was certainly well established by the mid-1780s.[42]

The piece was stopped up with a tapering wooden plug through which a hole had been drilled lengthways. Originally it had been driven tightly into the bore with a setter and mallet, but by the mid-1780s, due to problems in getting it out, the plug was lined with cow-hide and held in place by chains wrapped around the trunnions. The piece was filled with water, the vent was plugged, and a hose was screwed into the plug and attached to a pump. It was worked for about five minutes to attempt to force water out through any cracks which might be in the piece. If any water appeared the piece was rejected. When the water had been emptied out and the bore dried, a mirror was inserted to detect any holes or spunginess. Either sunlight or a special candle inserted in the bore would illuminate the mirror. The flaws, which would still be damp while the rest of the bore was dry, were thus easily detected.[43]

In 1782 Captain Thomas Blomefield was appointed Inspector General of Artillery at Woolwich, responsible for the proofing of ordnance. He entered into his job with great vigour and subjected the pieces to rigorous proofs. According to his proposed regulations for iron ordnance, should one gun in 10 burst, then the whole number submitted from that cast would be rejected immediately. If a smaller proportion failed, then the inspector could select two other guns which had been cast immediately before and after the burst gun, and fire each 20 times with the service charge. If either of them failed, the inspector could reject the whole batch (See Appendix A).

Such rigour was not appreciated by the contractors and a less demanding solution was worked out. If any gun were to burst, then all the guns of that batch would be subjected to a third proof, using the same charge as in the first two proofs. Any failure could result in the whole batch being rejected. According to the documentation, this was an arrangement worked out with the contractors, but not yet approved by the Board of Ordnance.[44] A later manual of 1801 notes:

> Ordnance suspected of being bad are often subject to a more severe proof; that of firing 30 rounds quick, with the service charge and 2 shot ...[45]

A survey of the manuals and notebooks after 1800 reveals that in all essentials the method of carrying on the proof continued much as it had before (See Appendix D for proof charges). The instruments used became more refined — for example, the handle of the seacher was graduated to aid in measuring and the pump became more powerful exerting more pressure on the water in the bore during the water test. A notebook of 1859 could almost have been written in the 1770s. It began:

> The examinations & proofs to which ordnance are subjected in this department are arranged as follows
>
> 1) instrumental proof.
> 2) fire proof.
> 3) searcher.
> 4) water proof.
> 5) sun proof.

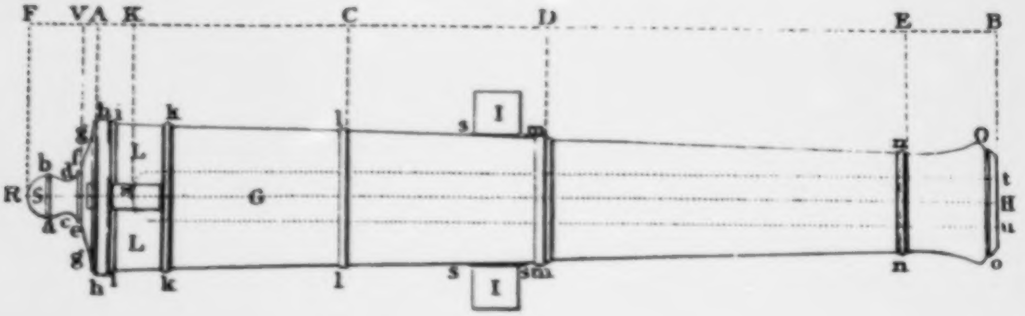
It then went on to describe Desaguliers' instrument used for ascertaining the size and trueness of the bore, and the various callipers and levels to measure the external surfaces. The method of fire proof was much the same except that by the later 1850s a galvanic battery was used to ignite the powder charge by transmitting an electric current through copper wires to the tube. The searchers were used in the usual manner and the gun was proofed with water and then with a mirror.[46]

The century and a half after 1700 saw a number of technological developments that resulted in British ordnance being arguably the best in the world by 1860. By the beginning of the eighteenth century gunfounders had discovered that brass, often called gun-metal (really bronze, an alloy of copper and tin) and cast iron were most suitable for the manufacture of ordnance. Because of its cheapness and less proclivity to damage, cast iron came to replace brass except for field pieces for which lightness was of more importance. In the first half of the eighteenth century British technology tended to lag behind developments on the continent where Maritz's invention of a horizontal, as opposed to a vertical, boring mill and the innovation of turning the artillery piece rather than the drill bit allowed ordnance to be cast solid and then accurately bored out. The Verbruggens, who replaced Andrew Schalch as master founder at the Royal Brass Foundry in 1770, introduced the new technology to England for brass ordnance in the early 1770s and the iron founder John Wilkinson adapted it to iron ordnance by the end of the decade. The adoption of a rigorous proofing system in the 1780s, under the supervision of Thomas Blomefield, Inspector

General of Artillery, along with the introduction of the new technology, ensured the quality of British smooth-bore ordnance for another 60 years. In the 1840s and 1850s new machinery and technical innovations were introduced into the Royal Brass Foundry to increase the efficiency of operation, but the processes remained essentially the same. By the 1850s the technology that had perfected smooth-bore muzzle-loading ordnance was being turned to the task of replacing it with rifled breech-loading artillery.

BRASS GUNS

Originally brass guns were cast in all calibres from the heaviest 42-pounder to the lightest 1-pounder (the 4-pounder seems to have been an exception) and they were used for all purposes — on ships, for sieges, and in the field. As explained previously, the heavier brass pieces were replaced by iron guns because of the latter's cheapness and durability, except in the field service where lightness was of more importance. By the 1760s field guns included 24-, 12-, 6-, 3-, and 1-1/2-pounders, but the 24-pounder came to be little used in the field and even the 12-pounder was awkward. (The 1-1/2-pounder was obsolete by the 1770s.) By the 1790s, when the 9-pounder field piece was introduced, the standard brass field guns were the 9-, 6-, and 3-pounders. (A 1-pounder or amusette has been recorded but its history is somewhat obscure.) The 9-and 6-pounders remained in service thereafter but the 3-pounder was relegated to colonial or mountain service where its lightness was of value in rugged terrain.



NAMES OF THE SEVERAL PARTS OF A GUN.

A B	*Length of the Gun*	L	*Vent Field*	h	*Base Ring*
A C	*First Reinforce*	N	*Vent*	i	*Base Ring Ogee*
C D	*Second Reinforce*	O	*Swell of the Muzzle*	k	*Vent Field Astragal & Fillets*
D E	*Chase*	VAK	*Breech*	l	*First Reinforce Ring*
E B	*Muzzle*	S	*Button*	m	*Second Reinforce Ring & Ogee*
F A	*Cascable*	a b	*Button Astragal*	n	*Muzzle Astragal & Fillets*
G H	*Bore*	c d	*Neck*	o	*Muzzle Mouldings*
R H	*Axis of the Piece*	e f	*Neck Fillet*	s	*Shoulder of the Trunnion*
I	*Trunnions*	g	*Breech Ogee*	t u	*Diameter of the Bore or Calibre*

Figure 1. The parts of a gun. (Griffiths, The Artillerist's Manual... (London, 1847), opposite p. 55.)

42-Pounder

Details about the 42-pounder brass gun are mostly lacking. James mentions it three times in his notebook, circa 1722. In 1715, a 10-foot version of 66 hundredweight was recommended for naval use. There also was a slightly shorter, and presumably lighter, model of 9 feet 6 inches. James included a table of dimensions given in Armstrong's regulations of 1725 that specified only the 10-foot model, but unfortunately the details are largely incomprehensible.[1]

The 42-pounder may have gone out of fashion temporarily for it was not included in the mensuration of 1743, the highest calibre recorded being a 32-pounder.[2] It was included in the Board of Ordnance's regulations of 1764 at 9 feet 6 inches in length and weighing 61 hundredweight.[3] Thereafter it was noted in various notebooks or manuals. Until the late 1770s it was usually cited at 61 hundredweight, after that its usual weight was said to be 66 hundredweight.[4] An increase of 5 hundredweight undoubtedly indicated some change in design, perhaps an increase of metal around the breech, but it is only speculation. The 42-pounder was last mentioned by Adye in his manual of 1813.[5] Hughes in his study was of the opinion that the gun was obsolescent by 1800 and obsolete by 1816.[6]

Thomas Walton, who was probably a civilian employee of the Board of Ordnance, was the only authority who recorded any dimensions, specifically those of the establishment (i.e., the official dimensions promulgated by the Board) in 1778.[7] Unfortunately, he gave only diameters, except for the length of 9 feet 6 inches.

Diameters	**ft.**	**in.**	**10th**	
On the base ring	1	9	75	?
Behind the 1st reinforce ring	1	7	0	
Before the 1st reinforce ring	1	6	166	?
Behind the 2nd reinforce ring	1	5	5	
Before the 2nd reinforce ring	1	4	5	
At the muzzle astragal	1	1	916	
At the muzzle swell	1	5	166	
Thickness of metal at the muzzle astragal		3	443	

32-Pounder

The 32-pounder brass gun is as obscure as the 42-pounder. Two lengths, 10 feet and 9 feet 6 inches, were recorded in James' notebook in the 1720s, but no mention of it was made in the table of dimensions laid down by Armstrong in 1725.[8] According to the mensuration of 1743, however, the gun was 10 feet long and weighed slightly more than 55-1/2 hundredweight.[9] There was no mention of a brass 32-pounder in the Board of Ordnance's regulations of 1764 nor by Walton in his table of 1778.[10] Adye, in his notebook of 1766, gave detailed dimensions of a gun 9 feet long. This is at odds with the rest of his table of guns which agreed with the mensuration of 1743.[11] A brass 32-pounder continued to be noted throughout the century, the last reference being in Adye's manual of 1813. Usually it was listed at 10 feet in length, weighing 55-1/2 hundredweight.[12] It is impossible to know if there were any changes in design since the only detailed specifications were those of 1743.[13] According to Hughes, the 32-pounder, like the 42-pounder, was obsolescent by 1800 and obsolete by 1816.[14]

24-Pounder

In the 1720s at least four different 24-pounder brass guns were reported. In one table, James listed the partial specifications of three of them, "according to the First and Second Regulation:"[15]

Length		Base ring to trunnion centre		Weight		
Ft.	In.	Ft.	In.	Cwt.	Qr.	Lb.
10	6	4	6	54	0	2
10	0	4	3	51	3	26 1/2
9	6	4	1		not given	

In another table, listing weapons according to Armstrong's regulations of 1725, he noted only one 24-pounder of 9 feet in length, with no weight given.[16] The lack of detail in the first table and the obscurity of it in the second, in which diameters of the piece were intended to be set out, make it impossible to describe these guns more fully. The distance from the base ring to the trunnion centre, given in the first table, approximates the proportion later attributed to Armstrong of 3/7 the length of the gun.

About 1750 Glegg copied into his notebook detailed dimensions, according to the mensuration of 1743, of a brass 24-pounder of 9 feet 6 inches, weighing 52 hundredweight, 1 quarter, 12 pounds.[17] Whether this was the same gun that James listed in the 1720s is impossible to say. A 24-pounder of this length, weighing 51 or 52 hundredweight, continued to be noted in books and manuals into the next century, the last reference to it being in Adye's manual of 1813.[18]

Two new models were brought into use about 1750: an 8-foot gun of 40 hundredweight and a 5-1/2-foot gun of about 16 hundredweight, both of which, according to the Aide-Mémoire, were intended for the field service.[19] All three varieties were included in the regulations of dimensions formulated by the Board of Ordnance in 1764, and they continued to be mentioned in books and manuals throughout the century.[20] Their weights tended to increase slightly by about 1780 which may indicate increases in diameters (see below).

According to a table of 1778, attributed to Congreve, there was a 24-pounder of 5 feet in length, weighing 16 hundredweight, 3 quarters, 13 pounds.[21] This length and weight of gun continued to appear subsequently and was included in Adye's manuals of 1801 and 1813.[22] The slightly longer gun of 5-1/2-feet also was noted, but no record has been found of both guns being recorded in the same table. It is quite possible that a new model was introduced, but it is equally possible that someone made a slight error in copying, an error which was repeated subsequently. After 1778 the weight of either length of gun was said to be 16 hundredweight, 3 quarters, 13 pounds (in one case only 13-3/4 hundredweight). A difference of 1/2 foot of metal should have made a difference in weight.

Probably in the 1790s Thomas Blomefield introduced a new light brass 24-pounder. It was slightly more than 6 feet 3 inches long, that is 13 calibres, and weighed 24 hundredweight, that is one hundredweight of metal for each pound of shot.[23] According to Hughes, this new gun shared the fate of the other three: all were "out of service after failure at the siege of Badajoz in 1811."[24]

There are a number of documents extant that illustrate these guns to a greater or lesser extent. Drawings of a 9 foot and a 9-1/2-foot brass 24-pounder, tentatively dated to circa 1735, from which exact dimensions can be extracted, have been preserved at the Royal Artillery Institution Library, Woolwich (Figs. 2 and 3).[25] An actual example from 1748, weighing about 50 hundredweight, is on display at the Rotunda, Woolwich, but unfortunately its length is not in the museum catalogue (Fig. 4).[26] Dimensions of a 9-1/2-foot gun were included in the "mensuration" of 1743, and these dimensions (with some differences), along with those of the 5-1/2-foot gun, were put into Adye's notebook of 1766.[27] Walton gave partial dimensions for the three models in 1778.[28] Finally, in 1791, Rudyerd made scale drawings of the heavy and medium guns during his course at the Royal Military Academy, Woolwich.[29]

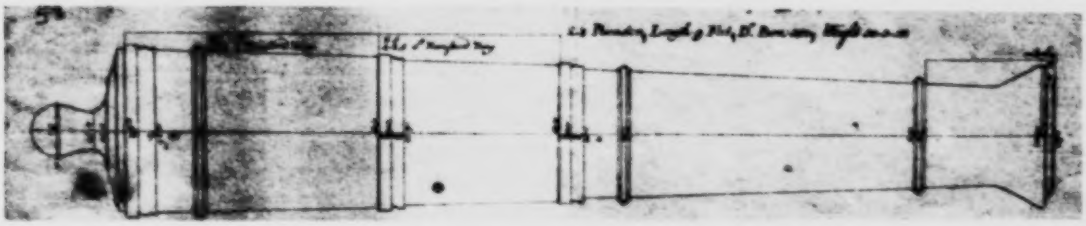


Figure 2. Brass 24-pounder, weight: 50 hundred weight 3 quarters 22 pounds, length: 9 feet. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

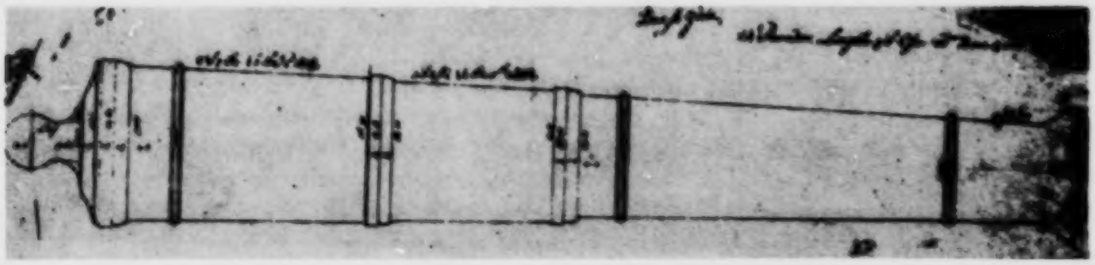


Figure 3. Brass 24-pounder, length: 9 feet 6 inches. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

The basic design of the heavy and medium guns, that is the number and arrangement of their parts, was very similar. The only differences, other than length, between the two guns in the circa 1735 drawings was the presence of a fillet behind each of the three rings of the 9 foot gun, while the 9-1/2-foot gun retained a fillet behind only the first reinforce ring. The 1748 gun at the Rotunda appears to match this latter drawing, including the single fillet behind the first reinforce ring. Rudyerd's drawing is similar except that the fillet has vanished. The only representation of the medium 24-pounder, by Rudyerd in 1791, showed that it followed the basic design of its heavier sister.

A comparison between the detailed dimensions of the circa 1735 drawing, the mensuration of 1743, and those given by Adye in 1766 of the 9-1/2-foot gun indicates

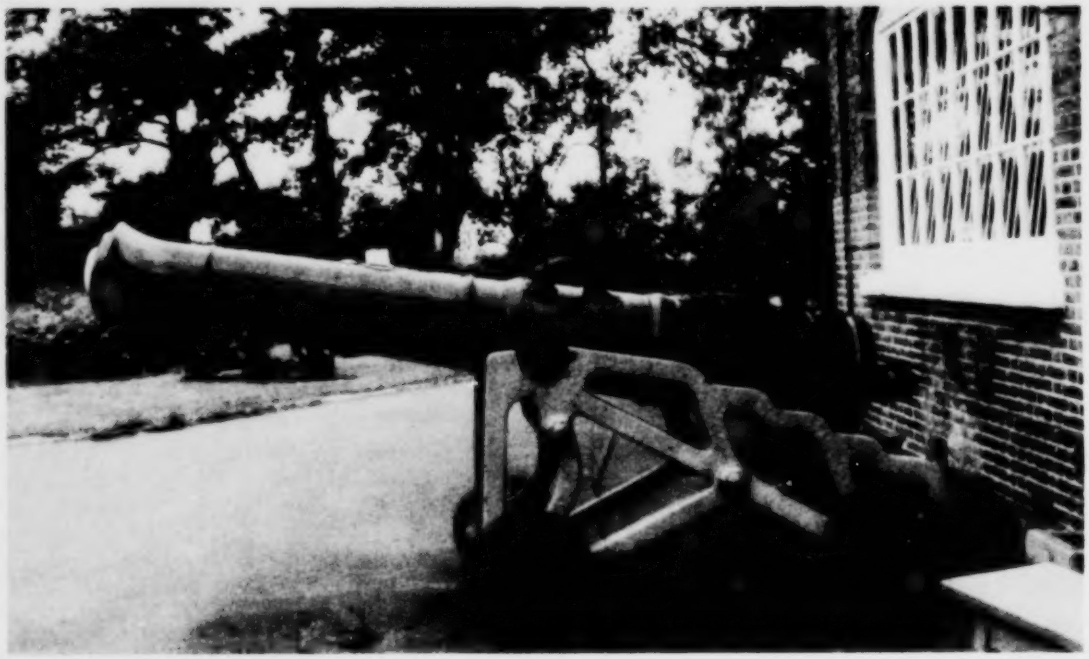


Figure 4. Brass 24-pounder, cast in 1748 by Andrew Schalch, weight: 50 hundredweight 2 quarters 24 pounds. It has been painted black. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/45.)

a great degree of similarity. The 1743 dimensions and Adye's, with two very minor exceptions, were identical in the body of the piece. Adye's dimensions showed, however, that the cascable had increased in length from 11 to 12 inches, with corresponding changes in the diameters of the fillets. The circa 1735 dimensions were very similar in diameters, but the lengths indicated slightly longer reinforces and a correspondingly shorter chase (a difference of 2.09 inches). Walton, for 1778, gave no lengths, only diameters or thicknesses of metal, which were consistently larger by about 1/4 to 1/2 inch. This increase in metal was reflected by the weights given: slightly more than 51-1/4 hundredweight in 1743 and 53-1/2 hundredweight in 1778. The gun drawn by Rudyerd in 1791 was lighter than either of these, slightly more than 50 hundredweight, and the dimensions, although not specifically stated, seem also to vary slightly. It is therefore very difficult to come to any general conclusions, except that between 1735 and 1791 there was little change in the overall appearance of the heavy brass 24-pounder of 9-1/2-feet.

There is less detailed information available about the medium gun of 8 feet. The earliest set of dimensions discovered, those set down by Walton for 1778, included, except for overall length, only diameters and thickness. He gave the length at 8-1/2-feet, but this must be an error, for elsewhere in his notebook he indicated that it was 8-feet long. Rudyerd drew a plan of a medium 24-pounder, 8 feet in length, weighing 2 pounds more than 41-3/4 hundredweight, the exact weight set down by Walton. The dimensions of the scaled drawing seem to be very similar to those given in 1778.

Although no drawings have been discovered of the light 24-pounder of 5-1/2-feet, Adye provided detailed specifications in 1766 and Walton set down its diameters for 1778. A comparison indicates, as in the case of the heavy gun, that the diameters had increased by the latter year and, it is assumed, the weight as well. According to the regulations of the Board of Ordnance in 1764, the light gun weighed 16 hundredweight 1 quarter 12 pounds while in 1778 it was listed at the increased weight of 16 hundredweight 3 quarters 13 pounds.

The appearance of this weapon was more simplified that the heavy and medium versions. In 1766 Adye noted:

> NB. These Guns [light pieces generally] have no other Mouldings besides y^{e} Base Ring & Ogee next to it. The Ogees have no fillets except that at the Muzzle which has two fillets like all other Guns & the Reinforce is join'd by a little Cavity. There is a small Ring cast under the Neck of the Cascable to fix the Elevating screw, which is used with light Field Pieces, instead of Coins or Wedges.[30]

In his table Adye gave the length of the vent field and the chase girdle, which implied the presence of the vent field and chase astragals and fillets, and he mentioned specifically the muzzle astragal. Walton's table in part confirms this description in that it left blank the diameters of the reinforce rings and recorded the thickness of metal at the muzzle astragal.

The 24-pounder described by Adye in 1801 as "Blomefield's," of 6 feet 3 inches and 24 hundredweight, undoubtedly was designed to replace the shorter light piece.[31] A formula for its construction was given in a manuscript notebook attributed to Isaac Landmann, *circa* 1790.[32] According to these notes its length was 6 feet 3.669 inches long or 13 calibres and its weight 24 hundredweight. (There may be a slight error as 13 calibres exactly would be 6 feet 3.699 inches, the calibre being 5.823 inches.) The design of the gun was a reversion to a more traditional outline. The two reinforce rings and the second reinforce ogee were put back on, but the chase astragal and fillets have vanished.

18-Pounder

The brass 18-pounder gun seems to have been a rather obscure weapon. Between about 1725 and 1780 it was recorded at various lengths from a rather short 7 feet 6 inches to 10 feet. By 1780 in its various manifestations it was probably obsolete, until, about 1790, it received a renewal of life when Thomas Blomefield brought forward his 18-pounder of 5 feet 9 inches and 18 hundredweight. The British artillery used the new weapon in the Peninsular campaigns, but withdrew it from service, along with the 24-pounders, after its failure at the siege of Badajoz in 1811.

In the second quarter of the eighteenth century three lengths of brass 18-pounders were identified. James listed two in his notebook, "according to the First and Second Regulation," at 9 feet and 9 feet 6 inches in length but he gave no weights. In addition he gave the lengths from the base ring to the centre of the trunnion, 3 feet 10 inches and 4 feet 1 inch respectively, that is about 3/7 the length of the gun which would be in accordance with Armstrong's proportions.[33]

Two drawings, tentatively dated *circa* 1735, depicted two 18-pounders, one 9 feet 6 inches and weighing 46 hundredweight 1 quarter 17 pounds, and the other 10 feet and weighing 54 hundredweight 1 quarter 12 pounds (Figs. 5 and 6). Detailed measurements were written on the drawings.[34] Except for a minor variation in the cascable design, the profiles of the two guns were identical, although the proportions of the lengths of the reinforces and chase to the total length were not exactly the same.

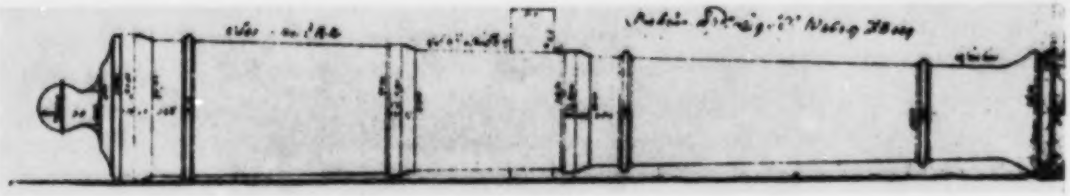


Figure 5. Brass 18-pounder, weight: 46 hundredweight 1 quarter 17 pounds, length: 9 feet 6 inches. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

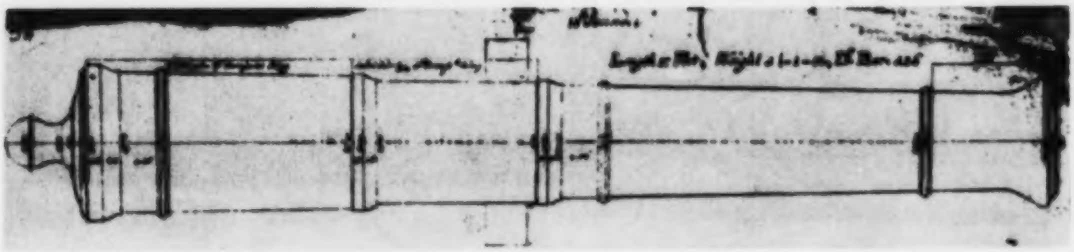


Figure 6. Brass 18-pounder, weight: 54 hundredweight 1 quarter 12 pounds, length: 10 feet. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

Although a 10 foot 18-pounder continued to be mentioned for another 40 years, no detailed measurements of it subsequent to 1735 have been found. There are, however, detailed measurements of the shorter gun recorded in 1743 and in 1766.[35] These three sets of dimensions were very similar. The diameters were practically the same but the reinforces of the circa 1735 gun were slightly longer with a correspondingly shorter chase (a difference of 3.49 inches). The only difference between the dimensions of 1743 and those of 1766 was that the length of the cascable had increased by 1766 from 10 to 12 inches, with corresponding changes in the fillet diameters. Otherwise the basic design was very similar.

Both these lengths of 18-pounder brass guns were mentioned in notebooks or manuals until about 1780.[36] Significantly, however, no 18-pounder was recorded in Walton's table of 1778.[37] In all likelihood, therefore, by the late 1770s the 18-pounder had become obsolete. Adye, in whose tables appeared other brass guns of the 1770s, failed to mention it in his manuals in the first decade of the nineteenth century.[38]

At this point three anomalous brass 18-pounders should be noted. In his An Universal Military Dictionary, George Smith claimed that in 1753 there was an 18-pounder ships gun of 9 feet and 48-1/4 hundredweight. He also recorded two other versions, one of 9 feet and weighing the extraordinary weight of 20-1/4 hundredweight and the other of 7 feet 6 inches and 27-3/4 hundredweight.[39] The light gun was probably the 18-pounder that Muller had cast for the East India Company, 9 feet in length weighing 2400 pounds or 21 hundredweight 1 quarter 20 pounds.[40] Smith said that the short gun was a garrison piece. All three guns were mentioned in a table attributed to William Cargreve in 1778.[41]

In 1801, Adye listed in his manual a new 18-pounder gun of 5 feet 9 inches and 18 hundredweight, attributed to Thomas Blomefield.[42] This gun, like the 24-pounder and 12-pounder of Blomefield's design, was 13 calibres in length (5 feet 8.796 inches exactly) with a proportion of 1 hundredweight of metal to 1 pound of shot. Undoubtedly it was designed at the same time as the other guns, that is in the 1780s or early 1790s.[43] According to Hughes it saw service in the Peninsular campaign but was no longer used after its failure at the siege of Badajoz in 1811.[44]

12-Pounder

The early history of the brass 12-pounder gun is obscure. In the 1720s James, in his notebook, gave some details on two models:

Length		Base ring to trunnion centre		Weight		
Ft.	In.	Ft.	In.	Cwt.	Qr.	Lb.
9	6	4	1	30	3	20 1/2
9	0	3	10			

The distance from the base ring to the trunnion centre is very close to 3/7 the length of the gun, which would match the proportions later ascribed to General Armstrong's construction. In another table, largely indecipherable, James also noted a brass 12-pounder of 8 feet in length, but nothing more is known of this gun.[45]

In a portfolio of drawings, circa 1735, there is extant a detailed plan of a 12-pounder of 9-1/2-feet weighing 21 pounds more than 44-3/4 hundredweight (Fig. 7).[46] Obviously, because of its great weight, this could not have been the gun noted by James. Interestingly, a brass 12-pounder of 9-1/2-feet and weighing 17 pounds more than 45 hundredweight was used in 1776 for experiments on different kinds of shot.[47] Probably such a heavy weapon was used because of its strength resulting from the thickness of metal around the bore, especially at the breech. No other record has been found of such a heavy 12-pounder; undoubtedly it was obsolete before the 1770s.

The standard heavy brass 12-pounder, for use in garrison, on ships, or as a battering piece, was 9 feet in length and weighed 29 hundredweight. Details of its dimensions were given in the mensuration of 1743.[48] The length and weight were the same as those given in the Board of Ordnance's regulations of 1764.[49] The 1743 dimensions were very similar to those given by Adye in his notebook in 1766, although there were some small variations in diameters, in the size of some of the mouldings, and an increase in 1766 in the length of the cascable.[50] While there would be little difference between a heavy 12-pounder cast according to the specifications of 1743 and one cast according to those of 1766, by the late 1770s there may have been some considerable increase in the thickness of metal. In 1778 Walton recorded diameters that were mostly greater than those of Adye, and he indicated that the weight of the gun had increased to 31-1/2 hundredweight.[51] This heavy brass 12-pounder continued to be mentioned throughout the rest of the eighteenth century, and was included in Adye's manuals of 1801 and 1813.[52] Undoubtedly it had become obsolete before 1800.

Sometime around 1750 two shorter and lighter models came into service — a medium gun of 6 feet 6 inches weighing about 21 hundredweight and a light piece of 5 feet weighing about 9 hundredweight. It is impossible to say precisely when they

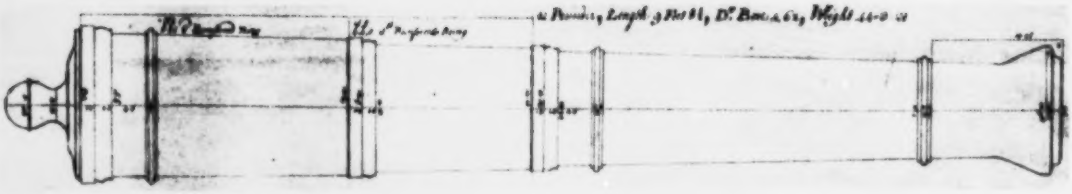


Figure 7. Brass 12-pounder, weight: 44 hundredweight 3 quarters 21 pounds, length: 9 feet 6 inches. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

were introduced. The 5-foot gun was mentioned in Glegg's notebook from the 1750s and in Muller's 1757 edition of his Treatise on Artillery.[53] The medium gun, along with the light piece, was included in the 1764 regulations of the Board of Ordnance.[54] Both guns were mentioned thereafter throughout the century and were listed in Adye's manuals of 1801 and 1813.[55] In all likelihood they had become obsolete before 1800.

Detailed specifications of the 5-foot field piece were given by Adye in 1766.[56] According to a note in Adye's notebook this gun, like the light 24-pounder, was simply designed, lacking reinforce rings and fillets, the second reinforce joining the chase by a small cavity or curve. Like its heavier sister it too had a ring cast under the neck of the cascable to which to fix the elevating screw. This would seem to be very similar to a gun of which Walton gave partial dimensions in 1778.[57] He included no lengths and only certain diameters, leaving out those of the reinforce rings, implying thereby that they did not exist. The diameters in his table, except for the muzzle swell, were consistently larger suggesting a somewhat heavier piece, although of the same general appearance.

There are no detailed dimensions of the medium 12-pounder, except for the diameters given by Walton in 1778.[58] In all likelihood its profile was similar to the heavy rather than to the light piece.

Both of these guns were included in Adye's manuals of 1801 and 1813, but by 1800 they were undoubtedly obsolete.[59]

Probably in the early 1770s an artillery officer, Thomas Desguliers, designed a new 12-pounder, 7-1/2-feet long and weighing about 22 hundredweight. It continued to be mentioned in notebooks and in Adye's manuals of 1801 and 1813, but it too was obsolete by 1800. It will be considered below in a separate section along with the 6-, 3-, and 1-pounders that Desaguliers also designed.

In the 1790s two new 12-pounders were added to the service which, according to Adye in 1801, "...are the only ones now used on general service."[60] One was a new medium gun, of the same length as the old, 6 feet 6 inches, but lighter at 18 hundredweight. The other was a light piece, 5 feet in length but weighing 12 hundredweight. Both these guns, according to Landmann's notes, circa 1790, were designed by Thomas Blomefield.[61] At least one of the new medium guns had been cast by 1794, when a committee of artillery officers recommended a casting of five new pattern pieces in order to compare them with the older pattern of 21 hundredweight.[62] The records are incomplete but presumably shortly thereafter the gun was officially sanctioned for service.

The medium 12-pounder remained in service during the rest of the smooth-bore era, but the light piece was not mentioned beyond the mid-1840s. In 1825 a student at the Royal Military Academy noted that the medium 12-pounder was "excellent," but remarked, perhaps jaundicedly, that the "Light 12 Pr might be of use in Canada and Countries of difficult movement."[63] It seems likely that the light piece saw little use. In the 1840s only the medium gun was included in the tables of brass pieces in the Aide-Mémoire and in the drawings and tables made by Boxer in 1853 for the students of the Royal Military Academy (Fig. 8).[64] As late as 1881 the 12-pounder of 18 hundredweight was still included in lists of weapons to be retained on active service.[65]

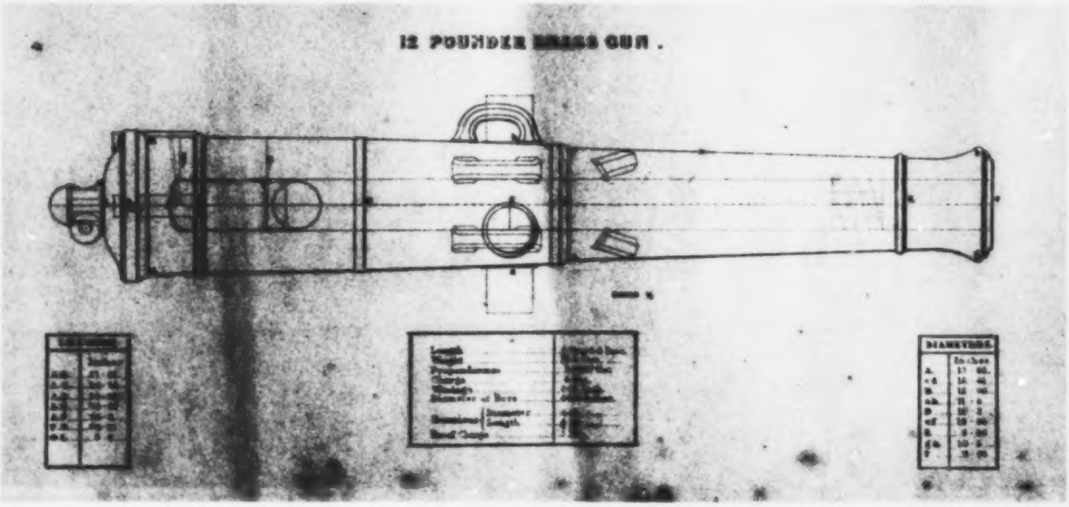


Figure 8. Brass 12-pounder, weight: 17.5 hundredweight, length: 6 feet 6.6. inches, circa 1850. (Boxer, Diagrams of Guns, Plate XIX.)

9-Pounder

In his notebook in the early 1720s James referred to three brass 9-pounders, but he gave no details of each gun other than its length and the distance from the centre of the trunnion to the base ring:[66]

Length		Trunnion centre to base ring	
Ft.	In.	Ft.	In.
9	6	4	1
9	0	3	10
8	6	3	8

If the measurement is from the rear of the base ring to the trunnion centre, in each case the distance is within a fraction of an inch of being 3/7ths the length of the gun, in accordance with Armstrong's system of proportions.

The subsequent history of the brass 9-pounder remains obscure for about the next 40 years. The table of measurements of 1743, contained in Glegg's notebook, contains a column for the gun's dimensions but it is entirely blank. Almost 20 years later, however, in 1764 a heavy 9-pounder, 9 feet in length and weighing 26 hundredweight, was included in the establishment of artillery of the Board of Ordnance.[67] In 1766 Adye gave detailed dimensions for this gun in his notebook.[68] In 1778 in his comprehensive table, Walton left the space for the heavy 9-pounder blank, but he did record it elsewhere in his notebook.[69] Undoubtedly the gun was obsolete by then.

Neither in Adye's nor in Walton's tables was there any mention of a light 9-pounder field piece. Yet Hughes in his study of British smooth-bore artillery maintains that a light 9-pounder was first cast in 1719 and cites Muller to prove its use during the campaign of 1747.[70] In his Treatise of Artillery Muller reproduced lists of guns, horses, and equipment of that campaign which included brass 9-pounders, but, since it required 11 horses to pull one gun, it seems likely that the gun referred to was the heavy, not the light, piece.[71] If indeed a light gun was used in 1747, it is clear that it was not in general use during the rest of the eighteenth century.

By the 1790s Thomas Blomefield had produced his system of design for guns, which included a brass 9-pounder of 17 calibres or 5 feet 11.4 inches in length and weighing 13-1/2 hundredweight.[72] It is not known when the Board of Ordnance ordered the production of this model, but by November 1805 it was being tested at Woolwich to ascertain its ranges.[73] The gun came into its own in 1808 when the British forces in Spain found that they were being out-gunned by French 8 and 12-pounders. A brigade of 9-pounders was brought in and it proved so successful that, by the time of the battle of Waterloo, Wellington had ordered that half of his troops of Horse Artillery were to be armed with the gun. By this time the field batteries were similarly equipped.[74]

Following Waterloo the 9-pounder became the standard gun of the Field Artillery, although the Horse Artillery reverted to the light 6-pounder. The gun was used extensively and achieved a degree of fame during the Crimean War (Fig. 9).[75] Its design underwent little change except for the addition of a dispart sight on its muzzle and the loss of its dolphins.[76] An example of the gun, cast in 1859, is preserved at the Rotunda, Woolwich (Fig. 10).[77] Nearby is what might have been an experimental model, cast in 1857. Except for the base ring all the mouldings have vanished, the two reinforces have been combined into one, and it joins the chase by a slight curve.[78] According to the catalogue of the Rotunda Museum, only a few guns of this pattern were manufactured (Fig. 11). The standard model was cast until 1862 and as late as 1881 was still on the active service list.[79]

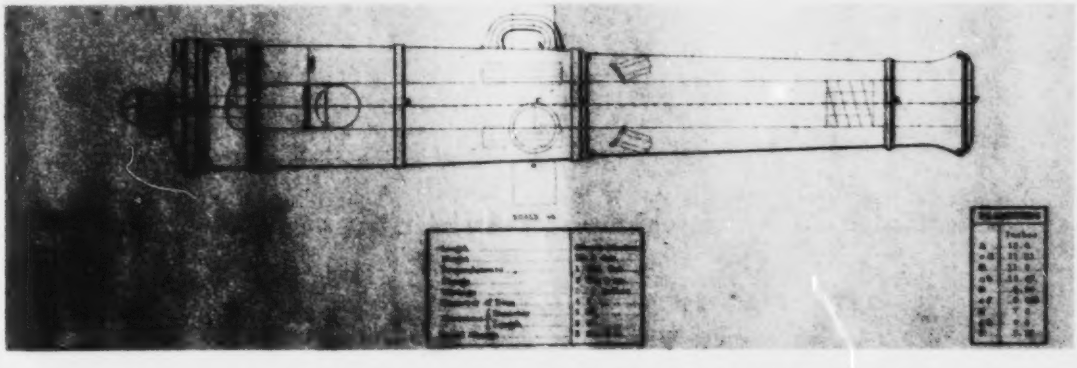


Figure 9. Brass 9-pounder, weight: 13.5 hundredweight, length: 5 feet 11.4 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XX.)

Figure 10. Brass 9 pounder, cast in 1859, weight: 13 hundredweight 2 quarters 1 pound, length: 6 feet. Cf. Figure 9. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/90.)

Figure 11. Brass 9 pounder, cast in 1857, length: 6 feet 7 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/91.)

6-Pounder

In the 1720s James listed four brass 6-pounders in his notebook:[80]

Length		Base ring to trunnion centre		Weight		
Ft.	In.	Ft.	In.	Cwt.	Qr.	Lb.
9	0	3	10	18	0	14
8	6	3	8		Blank	
8	0	3	5			
7	6	3	3			

In all cases the distance from the trunnion centre to the base ring is fractionally close to 3/7 of the length of the gun, in accordance with Armstrong's system of proportions. The weight given for the longest gun seems light. There is a drawing of a 6-pounder of 9 feet, circa 1735, which was said to weigh slightly more than 27 hundredweight.

Of these four guns all but the 8-foot one passed from the scene quite quickly. There are extant drawings, tentatively dated 1735, of brass 6-pounders of 9 feet and 8 feet in length (Figs. 12 and 13).[81] It is impossible to determine if these were of the same design as those of the 1720s; as noted above there was a discrepancy in the weights of the guns of 9 feet in length. The weight of the gun of 8 feet was not given on the 1735 drawing. The gun of 9 feet was last mentioned in a notebook, circa 1770.[82]

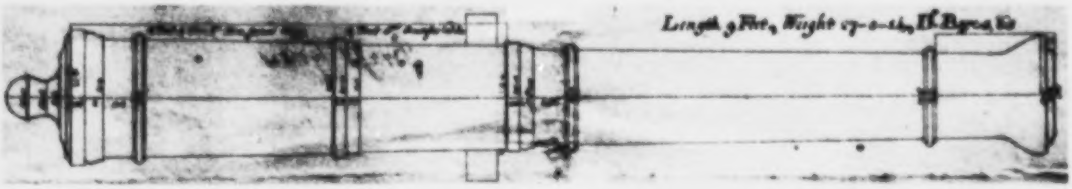


Figure 12. Brass 6-pounder, weight: 27 hundredweight 14 pounds, length: 9 feet. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

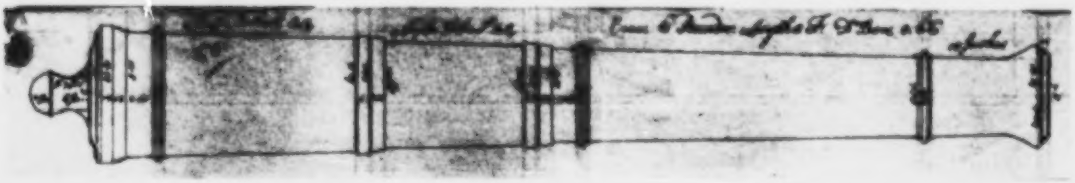


Figure 13. Brass 6-pounder, length: 8 feet. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

The gun of 8 feet and 19 or 19-1/4 hundredweight remained in service probably until the end of the 1770s. It was included in the table of mensuration of 1743 and listed in the establishment promulgated by the Board of Ordnance in 1764.[83] Adye gave detailed dimensions in his notebook in 1766 and Walton included it in his tables of diameters of 1778.[84] A comparison of the dimensions of *circa* 1735, 1743, and 1766 reveals that, except for the length of the cascable which in Adye's table of dimensions has increased by 3 inches, there were only a few fractional variations and that the design had remained unchanged. A further comparison with the diameters given by Walton also shows only minor variations of no significance. An example of this 6-pounder, cast by the Verbruggens in 1774 is held at the Rotunda, Woolwich, and, as far as can be determined without its detailed measurements, seems tocorrespond to the drawing of 1735, with the addition of dolphins (Fig. 14).[85] The gun was still listed by Adye in his manual of 1813, but it must have been long obsolete by then.[86]

Two smaller 6-pounders were also included in the establishment of 1764 — a medium gun of 5 feet and 10-1/4 hundredweight and a light gun of 4-1/2 feet and 4-3/4 hundredweight.[87] It is not known precisely when these guns were introduced, but the light piece was used in Flanders during the campaigns of the 1740s and Muller wrote of testing one that was at the battle of Lauffeldt in 1747.[88] Both models were noted by Glegg in his notebook of the 1750s.[89] An example of the light gun, cast by Gilpin in 1756, is held at the Rotunda, Woolwich.[90] It was being used as late as 1783 when it burst at St. Lucia in the West Indies. Despite a large section missing from the reinforces, it is still possible to understand its design (Fig. 15).

Adye set out detailed dimensions of the light field piece in his notebook of 1766.[91] Athough no exact measurements of the burst gun of 1756 have been made, it seems to match generally the dimensions given by Adye. Its weight, 4 cwt. 2 qr. 22 lb., agrees with that given in the regulations of 1764. There may, however, be a difference in detail for Adye appended a note to his table that "These Guns field pieces have no other Mouldings beside y^{e} Base Ring & Ogee next to it." Since he mentioned the vent field, chase girdle (both of which were in part delimited by an astragal), and muzzle astragal in his detailed specifications, presumably he meant merely that there were no reinforce rings and ogees. The gun of 1756 clearly has a first reinforce ring and ogee, but equally clearly no second reinforce ring or ogee. The second reinforce joins the chase by a shallow *caveto* or curve. Either Adye was in error or a minor change was made in design after 1756.

Neither the gun of 1756 nor that detailed by Adye was the same as a light 6-pounder that Rudyerd drew in his notebook in 1791.[92] The latter's length was the same, 4-1/2 feet, but it was slightly heavier, 5-1/4 hundredweight, and its proportions were different. This new gun was introduced into the service probbly in the 1770s, certainly by 1778. The diameters given by Adye in 1766 were significantly different from those given by Walton in 1778 (he gave no lengths); the latter matched those of Rudyerd's scaled drawing. [93] As well, references have been found beginning late in 1778 and continuing in 1780 to Capt. Congreve's light 6-pounder or to 6-pounders "of the new Construction," all 4-1/2 feet in length and weighing more than 5 hundredweight.[94] In his 1977 booklet on the light 6-pounder Adrian Caruana is of the opinion that the references to Congreve merely signified that the gun was mounted on the carriage designed by Congreve.[95] It is at least arguable that Congreve designed the new gun and that his name was attached to it in the same way that Belford's and Desaguliers' names were attached to the guns that they designed. On the other hand Rudyerd's drawing conforms to the dimensions given by Landmann in the 1790s which he attributed to Armstrong.[96] This light 6-pounder of 4-1/2 feet was listed in Adye's manual of 1813 but by then it was undoubtedly obsolete.[97]

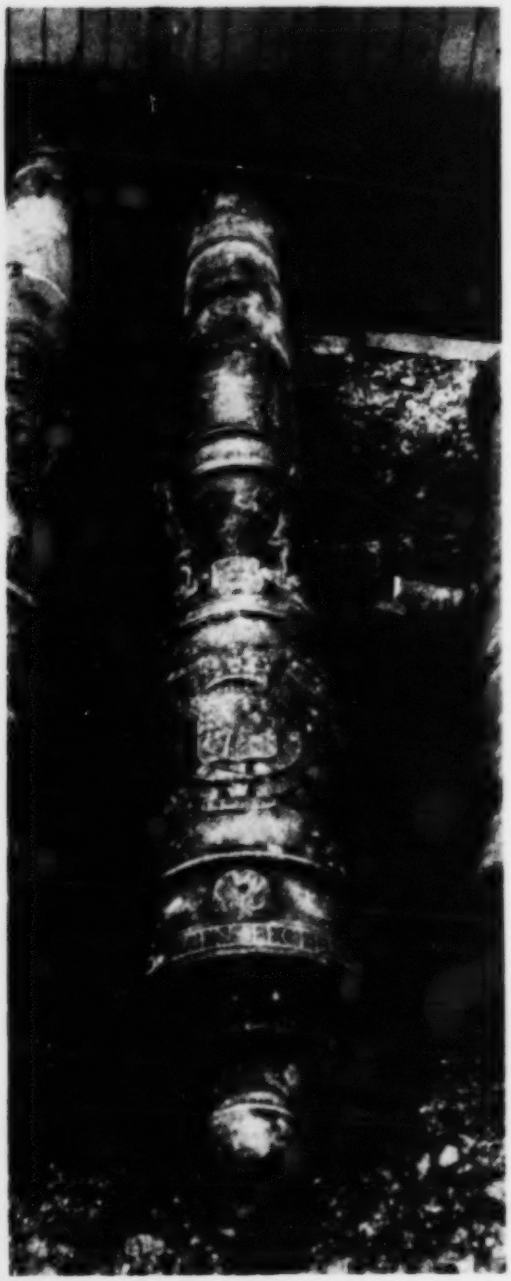


Figure 14. Brass 6-pounder, cast by the Verbruggens in 1774, weight: 19 hundredweight 2 quarters 6 pounds, length: 8 feet. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/59.)

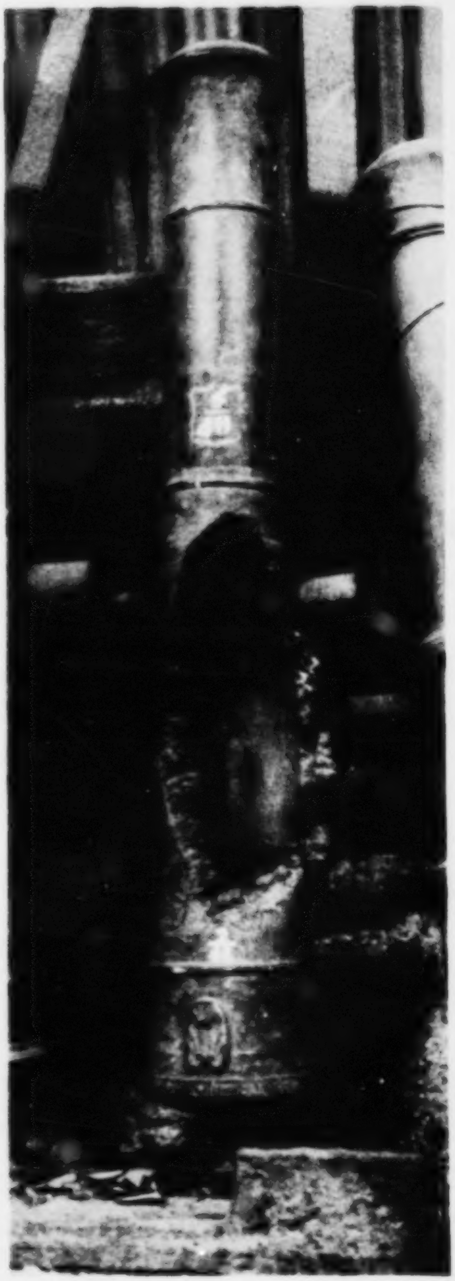


Figure 15. Brass 6-pounder, cast by Richard Gilpin in 1756, weight: 4 hundredweight 2 quarters 22 pounds, length: 4 feet 6 inches. Burst at St. Lucia in 1783. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/48.)

The other short brass 6-pounder which was in service by 1764 was a medium gun, 5 feet in length, weighing about 10-1/4 hundredweight.[98] Few details are available about this gun. Adye did not mention it in his detailed tables in 1766. In 1778 Walton recorded a medium 6-pounder, but stated its length at 7 feet and its weight at 12 cwt. 1 qr. 17 lb. This is the only reference to such a gun. It is impossible to say whether Walton was in error or whether such a gun existed. Elsewhere in his notebook he clearly referred to the medium 6-pounder of about 10 hundredweight.[99] Two examples of this gun, cast by the Verbruggens in 1778, are held at the Rotunda, Woolwich, both of which were rifled for experiments in 1790.[100] The design is like the heavier guns, not the light pieces, with the usual rings, ogees, and astragals. Both guns weigh slightly more than 10 hundredweight. One is said to be 5 feet in length, the other 5 feet 5 inches, but this latter measurement must be an error. This gun was included in Adye's manual of 1801 but not of 1813.[101] It was undoubtedly obsolete by 1800.

As well as Congreve's light 6-pounder, two other 6-pounders were probably introduced in the 1770s. One was designed by Thomas Desaguliers, 7 feet in length and weighing about 12-1/4 hundredweight. It will be dealt with below in a separate section. It is sufficient to say at this point that as late as 1825 it was in use. In that year Mould commented that it was "...Good Shooting but not good travelling gun."[102]

The second gun introduced in the 1770s was a light piece of 5 feet, weighing about 5-1/2 hundredweight, designed by William Belford, a distinguished artillery officer who had risen from a cadet in 1726 to become Colonel-Commandant of the Royal Regiment of Artillery by 1751.[103] In 1778 Walton listed a light 6-pounder of 5 feet but gave no weight; presumably this was Belford's gun.[104] It was mentioned by name during experiments held at Woolwich in December 1778 and at Winchester in August and September 1780.[105] There are also records of trials held in 1792 involving light 6-pounders of 5 feet and weighing slightly more than 5-1/2 hundredweight.[106] The details of the gun's construction are not complete since Walton gave only diameters, but there is extant a gun of 5 feet at the Rotunda, Woolwich, cast by Francis Kinman in 1794 (Fig. 16). No weight is given in the museum catalogue, but this probably is Belford's gun.[107] The gun was last mentioned by Adye in his manual of 1813.[108]

The last pages of Walton's notebook were devoted to range tables and experiments with case shot, including in part the use of brass 6-pounders. Three of these would appear to have been Desaguliers', Belford's, and Congreve's, but three others had not previously been recorded. One was 6 feet long and weighed 8:3:30 [sic, 20?]; the two others were each 5-1/2 feet long and weighed 8:3:37 [sic, 27?] and 8:0:22 respectively. The first of these latter two guns was refered to in two tables as "heavy"; the second gun as "reduced." In another table both appeared to be termed "heavy reduced." No date has been ascribed to these experiments, but since they follow tables dated 1792, it seems not unlikely that they were carried on in the early 1790s.[109]

In 1801 Adye did not include these guns in his manual; he listed only one medium gun of 5 feet and 10 hundredweight. By 1813 his manual had dropped this gun and added two medium guns, one called "new" of 6 feet and weighing 8:3:27 and the other called "reduced" of 5-1/2 feet and weighing 8:0:11.[110] These appear to be two of the three guns listed by Walton. Adye noted that the medium reduced, along with the gun of 7 feet, were the only 6-pounders on general service. Neither of these medium guns was mentioned after 1813 and both were probably obsolete before then.

As part of his system of gun design Thomas Blomefield produced the design for two 6-pounders in the 1790s, a heavy gun of 17 calibres or 5 feet 2.356 inches in length and weighing 9 hundredweight and a light gun, 5 feet in length and weighing 6 hundredweight (Fig. 17).[111] It is difficult to determine how extensively the heavy

Figure 16. Brass 6-pounder, cast by Francis Kinman in 1794, length: 5 feet. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/72.)

gun was used for it was rarely mentioned, but by 1825 Mould, in his notebook, commented that the 6-pounder, 5 feet in length and weighing 9 hundredweight (presumably Blomefield's gun, the length given being a slight error) was "not used." Its dimensions were given in Boxer's diagrams of the 1850s but it was not included in the tables of artillery in the Aide-Mémoire.[112] Presumably it was obsolete by 1820, probably because it gave little advantage over the light gun, while weighing 3 hundredweight more.

The light gun was in service as early as 1797, an example cast that year being in our Parks collection together with one of 1813 (Fig. 18). The Tower of London holds a similar piece cast in 1798.[113] This gun became the standard weapon of the Horse Artillery until it gave way to the 9-pounder Armstrong gun in the 1860s. It was reportedly last cast in 1862.[114] A comparison between drawings of the gun made in circa 1820 and Boxer's diagram of the 1850s shows no changes in design.[115] The precise dimensions were supplied by the Aide-Mémoire and the Boxer drawing; the minute differences in some of the measurements are insignificant.[116] The only change that occurred was the addition of a dispart sight on the muzzle in the 1850s. Three examples of the gun from this decade are at the Tower of London.[117] As late as 1881 it was still on the active list.[118]

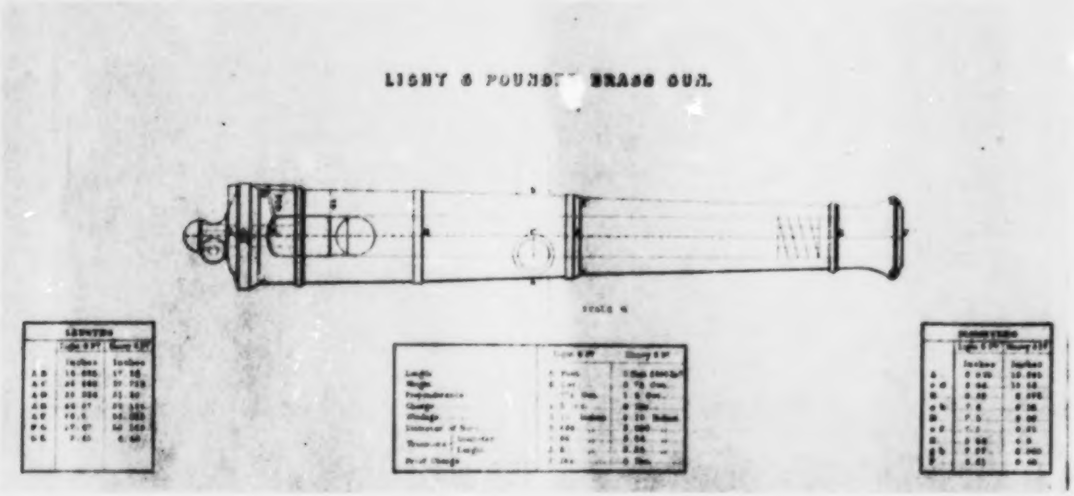


Figure 17. Light and heavy brass 6-pounders, (1) weight: 6 hundredweight, length: 5 feet; (2) weight: 8.75 hundredweight, length: 5 feet 2.356 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XXI.)

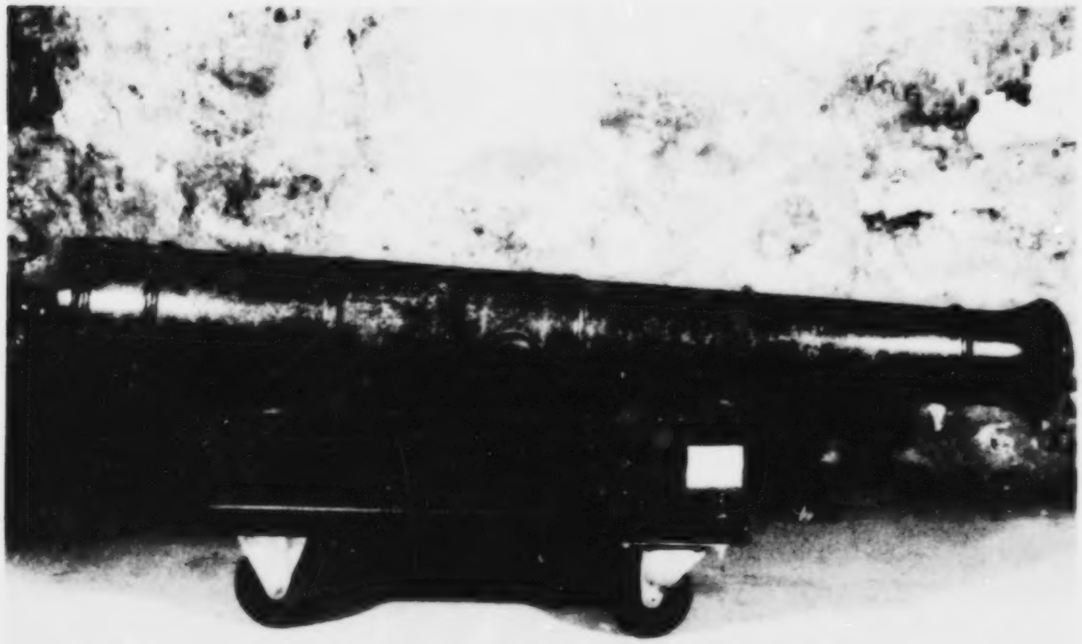


Figure 18. Light brass 6-pounder, cast by John and Henry King in 1797, weight: 6 hundredweight 1 pound, length: 5 feet. (Parks, Lower Fort Garry National Historic Park.)

3-Pounder

James listed four brass 3-pounders in his notebook of the 1720s:

Length		Base ring to trunnion centre		Weight		
Ft.	In.	Ft.	In.	Cwt.	Qr.	Lb.
7	0	3	0	10	2	0 1/2
6	6	2	10	8	3	18 1/2
6	0	2	7			
5	0	2	2			

The distance from the centre of the trunnion to the base ring is exactly 3/7 the length of the gun of 7 feet and is within fractions of an inch of this proportion in the other three guns. This would be in accordance with the proportions of the construction attributed to Armstrong.[119]

It is impossible to say precisely what these guns looked like, although the longest may have resembled the circa 1735 drawing preserved at the Royal Artillery Institution, of a brass 3-pounder of 7 feet (Fig. 19).[120] The dimensions of this latter weapon were very similar to those given in the mensuration of 1743 and by Adye in his notebook of 1766, the most noticeable difference being an increase of almost 4 inches in the length of the cascable between 1743 and 1766.[121] The collection of arms in the Tower of London contains a brass 3-pounder, cast in 1742, 6 feet 11 inches long, weighing 11 cwt. 3 qr. 19 lb., which is similar in design to the circa 1735 drawing and, as far as can be ascertained from a line drawing, appears to match closely the dimensions given in 1743.[122] The Board of Ordnance included a brass 3-pounder of 7 feet and 11-1/2 hundredweight in the establishment of 1764.[123] Although the gun was mentioned throughout the rest of the century and was included in Adye's manuals of 1801 and 1813, it seems likely that it had become obsolete before 1800.[124]

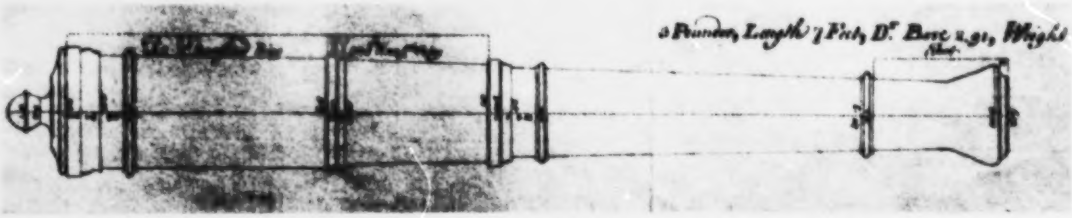


Figure 19. Brass 3-pounder, length: 7 feet. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

There seems to have been an attempt to develop a lighter brass 3-pounder of 7 feet in the late 1770s. Such a gun, weighing only 6 cwt. 3 qr. 3 lb., now in the collection at the Rotunda, Woolwich, was cast by the Verbruggens in 1777 (Fig. 20).[125] Walton referred to such a gun in 1781 but nothing more is known about it.[126] Presumably it was not successful.

Figure 20. Brass 3-pounder, cast by the Verbruggens in 1777, weight 6 hundredweight 3 quarters 3 pounds, length: 7 feet. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/63.)

As a complement to the heavy gun of 7 feet, a light 3-pounder of 3-1/2 feet and about 2-3/4 hundredweight was introduced into the service probably in the 1740s, but certainly by the 1750s. An example of this weapon, cast by William Bowen in 1756, has been preserved at the Rotunda, Woolwich.[127] The Board of Ordnance included it in the establishment in 1764 and Adye recorded it in his notebook two years later, but unfortunately, for reasons now unknown, he did not give any information about it other than its length of 3 1/2 feet.[128] In 1778 Walton gave partial dimensions, the various diameters but not the lengths of its components.[129] A second example of the gun, cast by the Verbruggens in 1782, is also at the Rotunda, Woolwich.[130] Although Adye included it in his manuals of 1801 and 1813, it was likely obsolete by 1800.[131]

Two other light brass 3-pounders were introduced into service in the 1770s. Both were 3 feet long, one weighing about 1-1/2 hundredweight and the other about 1-3/4 hundredweight. The lightest of the two was designed by a well-known artillery officer, James Pattison, and demonstrated before King George III at Woolwich early in July 1773.[132] Called a grasshopper, this gun was designed for rough terrain and could be carried, with its carriage and ammunition, upon two horses.[133]

The second gun, usually styled the "light infantry" 3-pounder, was slightly heavier. It was probably introduced later than Pattison's, although this is by no means certain, but by 1778 both were clearly in service according to Walton's list of that year.[134] Adye included both guns in his manuals of 1801 and 1813, but they were likely obsolete before 1800.[135]

Adrian Caruana devoted a booklet in 1980 to these guns in which he referred to two notebooks held by the Royal Artillery Institution, Woolwich, one of which was a list of drawings and the other the actual drawings. In the latter the draughtsman had illustrated an "Irish 3 Pounder" and "Lord Townshend's 3 Pounder." Caruana identified the Irish gun with Pattison's and the light infantry pattern with Lord Townshend's. He produced a scale drawing of each gun, presumably extrapolated from the illustrated manuscript although this is not made clear. Pattison's gun was a conventionally designed piece with the usual mouldings; the light infantry gun, on the other hand, has lost its reinforce rings and mouldings and seems to resemble the light infantry pieces that Adye described in his 1766 notebook.[136]

There are problems with Caruana's drawings, however. The diameters of Pattison's gun are consistently drawn larger than those of the light infantry pattern. This should mean that the former would be the heavier piece. But in various notebooks the weight of Pattison's gun consistently was given as being lighter than the other weapon. Moreover, according to the table of 1778 in Walton's notebook, the diameters of the lighter gun (i.e. Pattison's) were consistently less than the heavier gun (i.e. the light infantry pattern).[137] The reconciliation of Caruana's drawings with the evidence of the notebooks remains a puzzle.

During the 1770s, Thomas Desaguliers also designed a brass 3-pounder gun 6 feet in length and, according to Walton, weighing 5 3/4 hundredweight. Other notebooks usually indicated 6 hundredweight. This gun will be dealt with below in the section dealing with Desaguliers' construction.

By the 1790s new 3-pounders, designed probably by Thomas Blomefield, were introduced into service. According to Landmann's notes, Blomefield included two 3-pounders in his sytem. One was 17 calibres or 4 feet 1.521 inches long and weighed 4-1/2 hundredweight; the other was 6 feet long and weighed 6 hundredweight.[138] The evidence of the 3-pounders that are known to exist, however, indicates that a somewhat lighter gun was actually introduced. Parks collection contains six brass 3-pounders 4 feet in length, but weighing only slightly more than 3 hundredweight, all cast by John and Henry King between 1799 and 1810 (Fig. 21). Similar guns are at the Tower of London and at the Rotunda, Woolwich.[139] In appearance these guns seem to conform to the standard Blomefield construction, but they are lighter than the weight prescribed in his table.

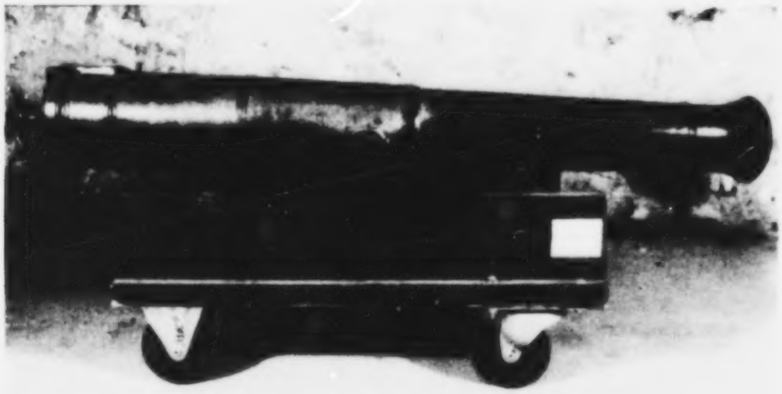


Figure 21. Brass 3-pounder, cast by John and Henry King in 1810, weight: 3 hundredweight 7 pounds, length: 4 feet. (Parks, Lower Fort Garry National Historic Park.)

There was also a shorter 3-pounder of 3 feet and weighing abut 2 1/4 hundredweight. Parks has an example cast by Kinman in 1812 (Fig. 22) and the Tower of London has another cast sometime between 1801 and 1810.[140] The Parks gun conforms to the usual Blomefield design, except there is no breech block to be drilled for a rear sight.

Neither of these patterns was included in Adye's manuals of 1801 or 1813, an omission which indicates that his information was not up to date. They are, however, listed in a revised edition of 1827 and in various other notebooks until the close of the smooth-bore era.[141] In 1825, Mould, a cadet at the Royal Military Academy, noted that the gun of 4 feet was "For Colonial Service" and that the shorter piece was designated for "Mountain Service."[142]

Probably in the early 1840s, a second pattern of a 3-pounder of 4 feet was introduced. The Aide-Mémoire of 1845 and 1853 listed two models, one styled "light" and the other "colonial." In 1849, Noble, a student at the Royal Military Academy, made the same distinction in his notebook.[143] A comparison of the dimensions given in the Aide-Mémoire with those given by Spearman in 1828 indicates that the gun termed "colonial" after 1845 was the new pattern. Its dimensions differed from those of the "light" gun by fractions of an inch; its bore diameter was slightly larger, 2.95 rather than 2.91 inches. Why it was considered necessary to create a new pattern with such minor variations remains a puzzle. According to the catalogue of the Rotunda, 3-pounders of 4 feet were not cast subsequent to 1859, although as late as 1881 the patterns of 4 feet and of 3 feet were still on the active service list.[144]

A heavy 3-pounder of 6 feet and 6 hundredweight continued to be recorded until the 1850s. In Adye's manuals of 1801 and 1813 it was designated "Desaguliers'" but thereafter either "long" or "heavy."[145] The dimensions given in the Aide-Mémoire in 1845 and 1853 are not in keeping with the proportions for Desaguliers' construction as outlined by Landmann in the 1790s.[146] Also, the length was given at 72.8 inches, 0.8 inch longer. Although it is difficult to say for certain, in all likelihood the Desaguliers' model was replaced by a pattern which probably resembled that suggested in Blomefield's table of construction. This gun was not mentioned subsequent to 1853 and was probably obsolete by 1850.

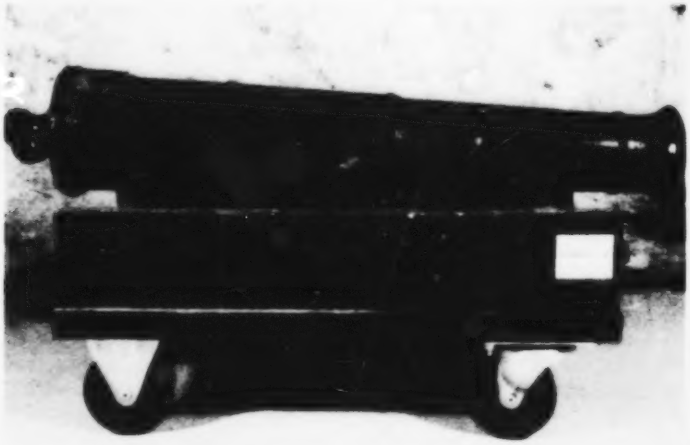


Figure 22. Brass 3-pounder, cast by Francis Kinman in 1812, weight: 2 hundredweight 14 pounds, length: 2 feet 11.9 inches. (Parks, Lower Fort Garry National Historic Park.)

1-1/2-Pounder

A brass 1-1/2-pounder seems to have been in service from about 1720 to the 1770s when it was superseded by the lighter 1-pounder or amusette. In the 1720s James recorded a 1-1/2-pounder of 6 feet in length, weighing 4 cwt. 2 qr. 22 1/2 lb. As in the case of the other guns in the table, the distance from the base ring to the trunnion centre was very close to 3/7 the length of the gun, 2 feet 7 inches.[147] This weapon was probably not the gun depicted in the scaled drawing of circa 1735 (Fig. 23).[148] The latter was also 6 feet long but it weighed more, 5 cwt. 3 qr. 24 lb. A brass 1-1/2-pounder was included in the mensuration of 1743 and in the establishment promulgated by the Board of Ordnance in 1764.[149] Its weight then was slightly reduced at 5-1/2 hundredweight. Walton provided a column for its dimensions in his table of 1778, but left it blank.[150] Undoubtedly the gun was obsolete by then.

The appearance and dimensions of the 1-1/2-pounder are provided by the scaled drawing of circa 1735, by the mensuration of 1743, and by Adye's notebook of 1766.[151] The differences in the three sets of dimensions are minimal. The major change by 1766 was the lengthening of the cascable and the moving of the trunnions slightly forward. Otherwise the gun of circa 1735 seems to have been very similar to that of 1766.

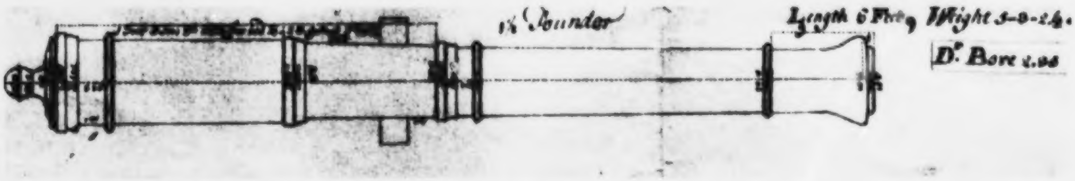


Figure 23. Brass 1 1/2-pounder, weight: 5 hundredweight 3 quarters 24 pounds, length: 6 feet. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

1-Pounder or Amusette

Brass 1-pounder guns were in service early in the eighteenth century. In the 1720s James listed a model 4 feet long and the catalogue of the Rotunda included 2 examples from the reign of King George II, each 3 feet in length and weighing 1 hundredweight.[152] Little is known about these guns, however. Neither the mensuration of 1743 nor the establishment of 1764 included this calibre. Only in the mid-1770s did the British develop the 1-pounder amusette.

The term amusette was first used by Hermann-Maurice, comte de Saxe, in his treatise on the science of warfare Mes Rêveries. Published in 1756, the treatise described a light, long-barrelled field piece, capable of long range and quick firing. Although de Saxe never developed the gun, a light 1-pounder was issued to the Norwegian and Danish infantry in 1758. The British did not design their version until 1776, presumably as part of the attempt to produce light pieces to serve in the rough terrain of North America.[153]

According to the gunfounder Pieter Verbruggen the British model was based on a 1-pounder of 1669 which was nearly 7 feet long.[154] A gun of this calibre, cast in

1776, 6 feet 11 inches long, weighing 3 cwt. 1 qr. 12 lb., is preserved at the Rotunda, Woolwich (Fig. 24).[155] It is long and slim and has the conventional mouldings of the period, except that it lacks the vent astragal and fillets. Also, the often elaborate vent shell has been reduced to a round raised circle of metal through which the vent has been drilled. Two other lengths, 5 and 6 feet, were also tried and after a series of experiments the pattern of 5 feet was accepted as standard.[156] The Rotunda also holds an example of this model, cast in 1782, weighing 2 cwt. 2 qr. 11 lb (Fig. 25).[157] Except for its length it resembles closely the pattern of 7 feet. The design of all three lengths of this gun was attributed to Thomas Desaguliers.[158]

Figure 24. Brass 1-pounder, cast by the Verbruggens in 1776, weight: 3 hundredweight 1 quarter 12 pounds, length: 6 feet 11 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/61.)

Figure 25. Brass 1-pounder, cast by Pieter Verbruggen in 1782, weight: 2 hundredweight. The total length is given as 5 feet 5 inches; the nominal length is likely 5 feet. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/70.)

British interest in the *amusette* returned in the early 1790s with the beginning of the French revolutionary wars. Once again a series of experiments were undertaken in 1794 using 1-pounders of 5, 6, and 7 feet to determine if the *amusette* should be reintroduced into service. One of these guns, of 5 feet and weighing 2 cwt. 2 qr. 3 lb., is preserved at the Tower of London.[159] Its design is different from the earlier guns of 1776 and 1782 and appears to conform to Thomas Blomefield's pattern.[160] According to Blackmore, "The experiments were evidently considered a failure as no more amusettes were produced."[161] In contradiction of Blackmore's assertion, a 1-pounder continued to be mentioned in notebooks and manuals until the early 1860s and its detailed dimensions were included in the tables of both editions of the *Aide-Mémoire*. It was often designated either "colonial" or "mountain."[162]

Desaguliers' Construction of Brass Guns

Beginning with Walton's table of 1778 there appeared in various notebooks and manuals references to General Desaguliers' guns, 12-, 6-, 3-, and 1-pounders, which, with the exception of the 1-pounder, seem to have been designed as alternatives to the common medium guns of the same calibre.[163] The designer, Thomas Desaguliers, who was the grandson of a Hugenot *emigré* and son of a well-known scientific thinker, had risen to prominence in the Royal Regiment of Artillery, from cadet in 1742 to Colonel-Commandant 20 years later. Since 1748 he had also been Chief Firemaster at Woolwich, in which capacity he had devoted himself to the scientific study of gunnery until his death in 1780.[164] Sometime before 1778 he produced his method of construction of medium brass guns.

Since his journals or notebooks have not survived it is impossible to know for certain what were his principles of construction. Fortunately Walton, in 1778, recorded the diameters of his guns and Landmann, in the 1790s, set down the construction of his 6-pounder.[165] It is reasonable to assume, although perhaps mistakenly, that the proportions given for the 6-pounder were the same for the other calibres. The diameters derived from Landmann's notes compare very closely with those given by Walton in 1778, with the exception of the diameter of the muzzle-swell of the 1-pounder. Unfortunately there is no similar table of lengths of reinforces and chase to set against those provided by Landmann. According to the latter a Desaguliers gun had a long first reinforce, a short second reinforce (less than 1/2 the length of the first), and a chase slightly more than 1/2 the length of the gun.

Desaguliers' guns weighed about the same as the common medium guns but, except for the 6-pounder, were longer.[166]

	Weight						**Lengths**			
Calibre	**Common**			**Desaguliers**			**Common**		**Desaguliers**	
	cwt.	**qr.**	**lb.**	**cwt.**	**qr.**	**lb.**	**ft.**	**in.**	**ft.**	**in.**
12	21	3	0	23	0	0	6	6	7	6
6	1	0	12	1	1	0	7		7	
3	6	0	0	5	3	0	3	6	6	
1				2	2	0			5	

What he seems to have done was to distribute about the same weight of metal over a longer length of gun, presumably with the intent of increasing the range and accuracy of the piece without decreasing its mobility. The 1-pounder was a new gun in the 1770s which was probably designed to replace the heavy 1-1/2-pounder.

The 1-pounder remains problematic. As previously noted, three lengths, 5, 6, and 7 feet, were tested in the late 1770s, the design of which was attributed to Desaguliers. Two examples, one of 7 feet cast in 1776 and the other of 5 feet cast in 1782, have survived (see above Figs. 24 and 25). Their weight matches that assigned to Desaguliers' construction, but the proportions of the length of the reinforces are clearly not those of the 6-pounder described in Landmann's notebook.

It is not known how many of Desaguliers' guns were constructed, nor where nor how extensively they were used. They seem to have become obsolete by 1800 and, in the case of the 3- and 6-pounders, to have been replaced by similar guns of Blomefield construction (see above).

CAST-IRON GUNS

The history of cast-iron guns is the converse of brass. In 1700 both cast iron and brass were used for almost all calibres but by mid-century, despite its weight, cast iron was replacing brass because of its cheapness and durability. The exception was field guns. Guns were manufactured in cast iron in all calibres up to 42-pounder. The latter seems to have been mainly in use on the lower decks of the largest line-of-battle ships, but was obsolete by the 1820s. Although the different calibres could have many uses, the standard siege gun was the 24-pounder and the standard broadside gun on line-of-battle ships was the 32-pounder, especially the weapons designed by Thomas Blomefield in the late 1780s or 1790s. These were excellent guns. The development of armour-plated steam-ships promoted the search for heavier, longer-ranging weapons to be mounted in shore batteries and on war-ships. New patterns of an old calibre, 42-pounder, and of a new calibre, 56-pounder, were designed, but both were only limited successes. However, an even heavier gun, the 68-pounder, was perhaps the finest smooth-bore cast-iron gun designed, particularly the model of 10 feet and 95 hundredweight.

68-Pounder

The 68-pounder was the most successful of the three new heavy guns brought into service in the 1840s (the others were the 42 and 56-pounders). According to Miller, it "is the most powerful smooth-bored gun in the service; it gives the longest ranges, throws the greatest projectile, and is generally the most accurate in its fire...."[1] Two 68-pounders of 110 and 112 hundredweight, which were first tested about 1839, were found not to be superior to the 56-pounder, but in 1841 a pattern designed by Colonel Dundas, 10 feet 10 inches in length and weighing 112 hundredweight, was accepted into service.[2] Dundas was also responsible for introducing two lighter and shorter models, one of 10 feet and 95 hundredweight, in 1846, and another of 9-1/2 feet and 88 hundredweight, shortly thereafter.[3] All three were intended for naval service, but because the 112 hundredweight gun was found to be too heavy to work easily on shipboard, it was relegated to coast defences. Even so it was never popular; in 1857 only 11 were in use and another seven were in store.[4] The 88 hundredweight gun, exclusively a naval weapon, also was not much used; in 1857 only six were mounted on board ship and 19 others were in store.[5] The most popular was the 68-pounder of 10 feet and 95 hundredweight, which was employed either as a pivot gun for steamers and men-of-war or in coast batteries.[6] By 1862, 1972 of this pattern had been cast.[7]

In 1859, the Committee on Ordnance recommended that the 68-pounders of 112 and 88 hundredweight be kept in service but that no more be manufactured, and that a new gun of 10 feet and 100 hundredweight be tested to replace that of 95 hundredweight.[8] It is not known if such a weapon was tried, but in 1865 the 95 hundredweight gun was ordered retained in service. Many were converted into 80-pounder rifle muzzle loader (R.M.L.) guns.[9] The heaviest was to be retained only until it could be replaced by rifled pieces.[10] The lightest 68-pounder was declared obsolete in 1865.[11]

There is no lack of information on the design and dimensions of these guns. In 1853, Captain E.M. Boxer prepared detailed dimensions and a diagram for the three

68-pounders (Fig. 26).[12] The *Aide-Mémoire* of 1845 gave the dimensions only of the 112 hundredweight gun; the 1853 edition added those of the 95 hundredweight gun.[13] All three sources were in agreement. The only change in design appears to have been the strengthening of the breeching loop of the 95 hundredweight gun, ordered in September 1860, because of which its weight increased by 22 pounds.[14] An example of this gun, cast in 1858, is extant at the Halifax Citadel (Fig. 27).

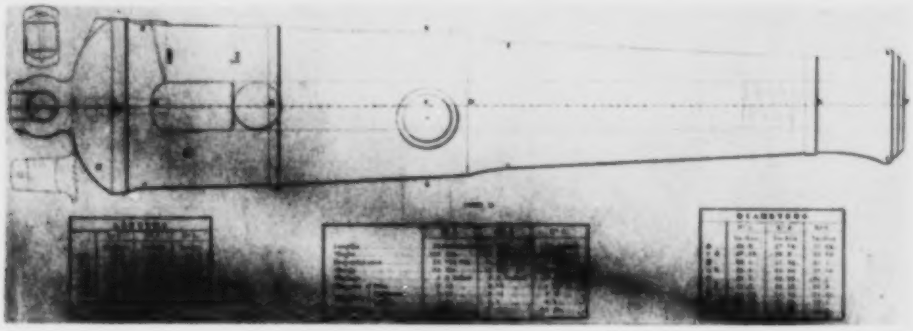


Figure 26. Iron 68-pounder, (1) weight: 113 hundredweight, length: 10 feet 10 inches; (2) weight: 95 hundredweight, length: 10 feet; (3) weight: 87 hundredweight, length: 9 feet 6 inches, *circa* 1850. (Boxer, *Diagram of Guns*, Plate II.)

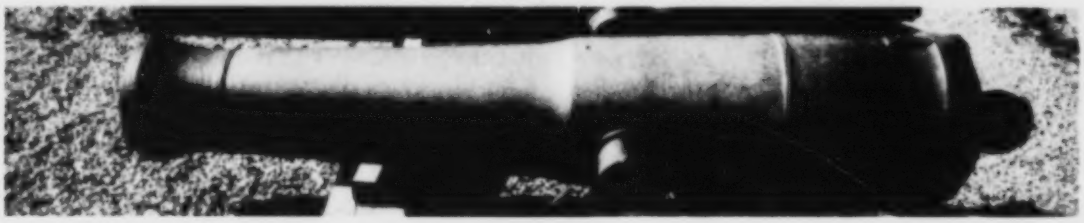


Figure 27. Iron 68-pounder, cast in 1858, weight: 95 hundredweight 1 quarter, length: 10 feet. (Parks, Halifax Citadel National Historic Park.)

56-Pounder

In 1838, T.B. Monk, clerk and draughtsman in the Department of the Inspector of Artillery, brought forward a new principle of construction of iron guns. He proposed keeping unchanged the ratio of the weight of the gun to that of the shot (about 1-3/4 hundredweight in the gun to each pound in the shot), but at the same time increasing the thickness of metal around the charging cylinder (where the cartridge and shot rest in the bore) while diminishing it in the chase. This principle was first applied to the design of a 56-pounder, 11 feet long and weighing almost 97-3/4 hundredweight, which was successfully tested at Deal in 1839. Monk's purpose in designing this new gun

> was to obtain by it more efficient and accurate practice at great ranges for general service, but more particularly for

> coast defences, in which artillery having the greatest powers of range seaward is of the utmost importance.[15]

A second version of 10 feet and 87 hundredweight was first constructed in 1844 (Fig. 28).[16]

Unfortunately, this straightforward account becomes complicated. In 1845, Fitzhugh wrote in his notebook:

> The 56 Pr. is a new gun to throw solid shot, originally intended for coast batteries, it is called Monk's gun. There is another made by Col. Dundas.[17]

It might be thought that Col. Dundas' gun was the new 56-pounder of 10 feet, but there is a scale drawing, circa 1848, entitled "Lt. Col. Dundas's 56 Pr. of 11 feet and 98 cwt" (Fig. 29).[18] At first glance Dundas' gun appears similar to the scale drawing of the gun of 11 feet prepared by Captain E.M. Boxer in 1853, but a closer look reveals cetain differences. While the lengths of the reinforces, chase, and muzzle are not significantly different, the trunnions of Dundas' gun are positioned 3.3 inches further forward. Also, Dundas has moved metal around, decreasing the thickness of the reinforces and increasing that of the chase. As well, the bore is almost an inch longer. How this reapportioning of metal affected performance is not known. These are the only references to Dundas' 56-pounder; the dimensions for the gun of 11 feet given by Boxer and in the Aide-Mémoire (which show no significant variations) and by Miller, in 1864, (though less complete), were not the same as those of Dundas' gun. Also, both in the Aide-Mémoire and in Miller's work, Monk's name was attached to the 56-pounder construction.[19] Dundas' variation may have been no more than an unsuccessful attempt at improvement.

A second complication is that there may have been two models of the 56-pounder of 10 feet, one weighing 87 and the other 85 hundredweight. Both Boxer and the Aide-Mémoire gave the gun's weight as 85 hundredweight. The Committee on Ordnance, 1857-9, gave both weights and treated each as distinct guns. All 42 of the guns of 85 hundredweight were in use, either in England or abroad, while all 18 of the guns of 87 hundredweight were in store in England.[20] Perhaps the latter weight of gun may have been an improvement of the 85 hundredweight model. It is the gun of 87 hundredweight that Miller recorded in 1864, but he wrote that it was first constructed in 1844 and gave no indication of a lighter version.[21]

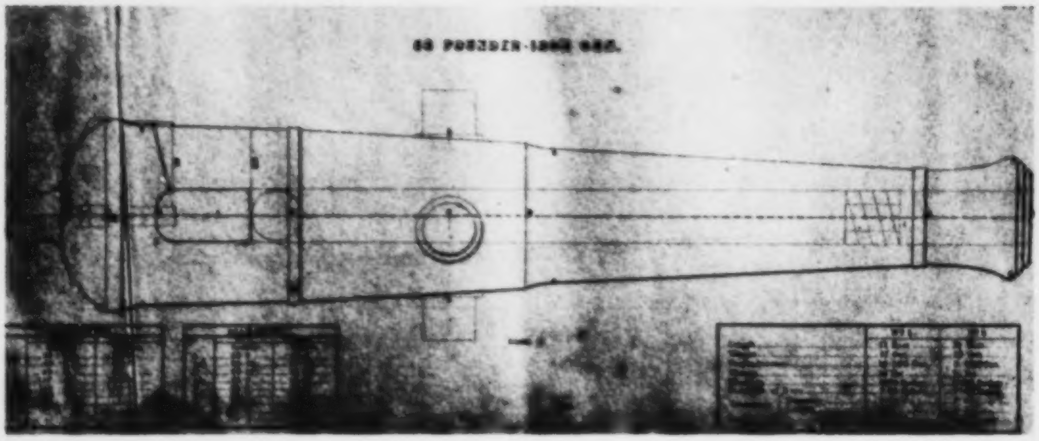


Figure 28. Iron 56-pounder, (1) weight: 97 hundredweight, length: 11 feet; (2) weight: 85 hundredweight, length: 10 feet, circa 1850. (Boxer, Diagrams of Guns, Plate V.)

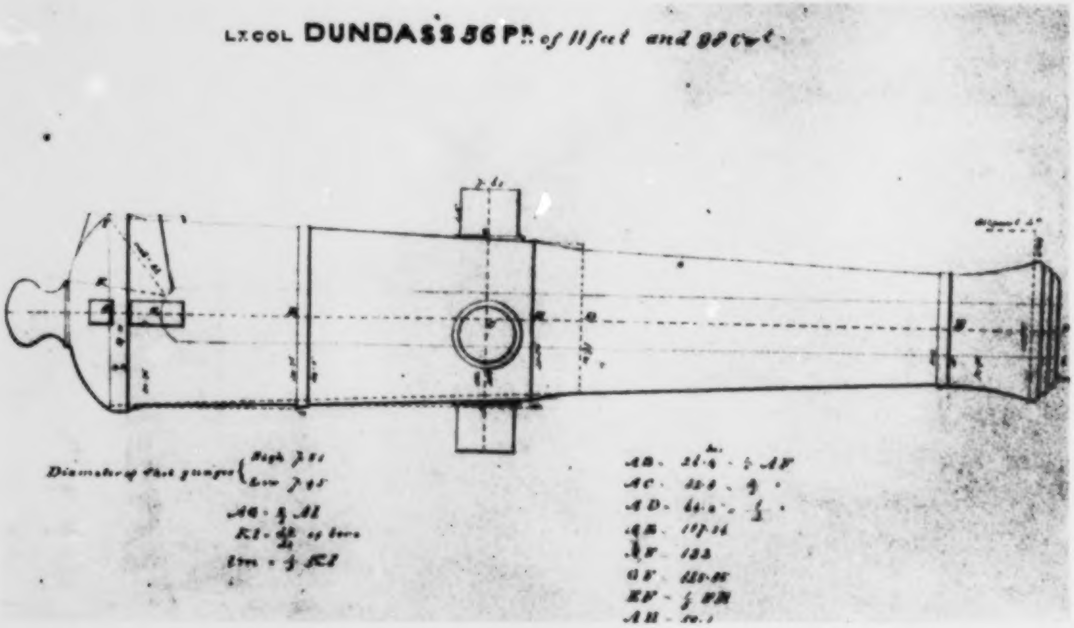


Figure 29, Iron 56-pounder, weight: 98 hundredweight, length: 11 feet, circa 1850. (The Royal Artillery Institution, Woolwich, U.K., Strange, "Drawings on Artillery.")

The 56-pounder was not a successful weapon. Because it had a reduced windage (0.175 inch) it shot well, but it was considered to be of a weak construction.[22] It had some popularity in coastal batteries and even on ships, but it was replaced by the 68-pounder.[23] In 1857, according to the Committee on Ordnance, 42 of the guns of 85 hundredweight were in use; 18 guns of 87 hundredweight and 10 guns of 98 hundredweight were in store.[24] In consequence the Committee recommended that the gun of 85 hundredweight might be retained but was not to be replaced, while the other models more to be declared obsolete.[25] In 1865, it was ordered that 56-pounders were to be retained only until they could be replaced by other pieces.[26]

42-Pounder

Although the cast-iron 42-pounder gun was clearly referred to in the first half of the eighteenth century, it was not a common gun and not a great deal is known about it. James' notebook of the early 1720s is characteristically laconic, giving only the guns four lengths - 10, 9-1/2, 9, and 8-1/2 feet.[27] A drawing of a 42-pounder, circa 1735, is accompanied by the following modern handwritten note:

> The 42 pounder Iron is probably an older pattern still in use [in 1735]. Borgard's iron 42 pounder was produced in 1716, and a plan exists of it; they are not the same. There is very little mention of 42 pdrs. in the early 18 century, it being only mentioned at Minorca in the war of the Spanish Succession;

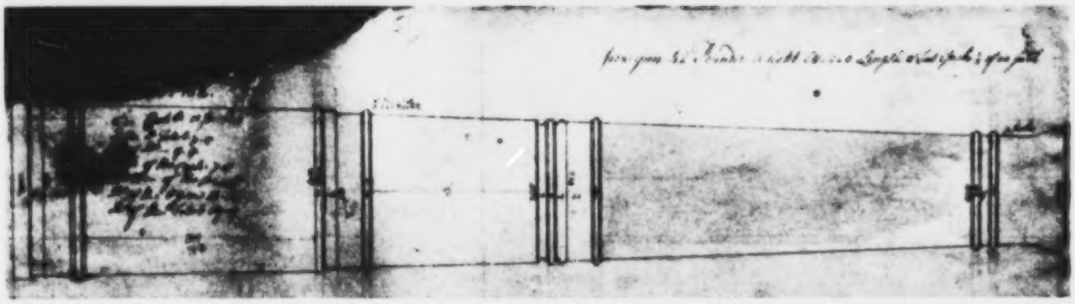


Figure 30. Iron 42-pounder, weight: 68 hundredweight 2 quarters, length: 11 feet 1.25 inches. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

> this 42 could well be the pre-Borgard pattern, possibly Martin Beckman.

The appearance of this gun is unlike the others included with it in a portfolio of drawings: it has more astragals and the second reinforce ring is strangely composed of a series of mouldings, seemingly a caveto, an astragal and fillets, and an ogee. Its length was 11 feet 1-1/4 inches, quite long, and its weight was 68-1/2 hundredweight, relatively light for its length (Fig. 30).[28]

By 1764, there may have been two 42-pounders in service. In 1753, a ship's 42-pounder 10 feet long and weighing slightly more than 55-1/4 hundredweight was noted.[29] The establishment of 1764 indicated only one 42-pounder of 9-1/2 feet, weighing 65 hundredweight, much heavier than the ship's gun.[30] In 1780, Walton gave dimensions for a gun of 9-1/2 feet but, according to him, weighing only 61-1/2 hundredweight. In 1781, he referred to guns 10 and 9-1/2 feet.[31] Other sources around 1780, recorded a 42-pounder of 10 feet and 67 hundredweight and of 9 1/2 feet and 65 hundredweight.[32] In 1781, Mountaine claimed in his manual of naval gunnery that twenty-eight 42-pounders formed the armament on the lower deck of first rates of 100 guns; these, he wrote, weighed 65 hundredweight.[33] All in all, the evidence for this period is rather confusing.

By about 1790, as part of his formula of construction, Blomefield produced specifications for a 42-pounder of 9-1/2 feet, weighing 65 hundredweight.[34] Whether or not this gun was ever constructed cannot be ascertained, but at Signal Hill National Historic Park, there is a Blomefield model 42-pounder, bearing the cypher of King George III, which is, remarkably, 12 feet in length (Fig. 31). In 1801 and 1813, Adye listed in his manual 42-pounders of 9-1/2 and 10 feet, weighing 65 and 67 hundredweight respectively, but these quite likely were the pre-Blomefield guns.[35] In 1825, Mould noted that the 42-pounder of 9-1/2 feet and 65 hundredweight was "obsolete. There may be some in Garrisons."[36]

In his study, Naval Gunnery, Sir Howard Douglas wrote that the regulation assigning 42-pounders to the lower decks of some line-of-battle ships remained in force until 1839, but quite likely it had been long ignored, for the 32-pounder, again according to Douglas, was the heaviest gun in naval service in 1838.[37] By the end of the 1830s the Ordnance was searching for heavier guns, and in 1839 at Deal, a 42-pounder of 10-1/2 feet and weighing 80-3/4 hundredweight was tested.[38] This initial design seems to have been unsuccessful, for a slightly shorter but heavier 42-pounder, 10 feet long and weighing 84 hundredweight, was introduced into the service. (Miller wrote that the pattern dated from 1839; Owen and Porter that it was introduced in 1843.)[39] In 1845, a 75 hundredweight gun, of the same length and, in 1846, a gun of 9-1/2 feet and 67 hundredweight were cast (Fig. 32).[40] The guns of 10 feet were designed by Monk, that of 9-1/2 feet by Colonel Dundas.[41]

All three patterns were initially designed for sea service, but they were available for defensive positions, at least on a contingency basis in the early 1850s.[42] In the naval service the gun of 9-1/2 feet was the most efficient. It was introduced as the lower-deck guns of "Blenheim" and "Ajax," steam guard-ships for dockyards, but it was found to be too heavy, requiring a crew which overcrowded the decks. Consequently, it was replaced by the 32-pounder of 56 hundredweight.[43] Indeed by the mid-1850s, all 42-pounders were considered obsolete although they remained in service for a number of years.[44] In 1865, the 84 and 67 hundredweight guns were ordered to be retained but only until they could be replaced by rifled pieces; the 75 hundredweight gun was declared obsolete.[45] In 1881, Owen and Porter noted, "42-prs. are rare; a few may yet be found mounted in out-of-the-way batteries."[46]

Figure 31. Iron 42-pounder, Blomefield design, length: 12 feet. (Parks, Signal Hill National Historic Park.)

Note concerning sources

Most sources agree that there were three 42-pounders in service during the 1840s - two models each 10 feet in length and weighing 84 and 75 hundredweight respectively, designed by Monk, and a third model 9-1/2 feet in length and weighing 67 hundredweight, designed by Dundas. This relatively straightforward account is complicated by certain problems. The Aide-Mémoire in 1845 gave deminsions of a 42-pounder of 9 feet 6 1-2 inches, weighing 85 hundredweight; nowhere else was a gun of such a length and weight recorded.[47] While the Aide-Mémoire of 1853 and Boxer's tables were in agreement on both 42-pounders of 10 feet, there were slight variations in their dimensions of the gun of 9-1/2 feet and 67 hundredweight.[48] The Aide-Mémoire indicated that its construction was "0" (standing for ordinary) that usually meant Blomefield construction. Since the proportions were not Blomefield's, this designation must be in error. The failure of these sources to agree completely is slightly disconcerting.

More mystifying is the evidence submitted to the Committee on Ordnance, appointed in 1857. According to its records there were six 42-pounders in existence in 1857:

Length		Weight	In use	In store	Total
Ft.	In.	Cwt.			
10	6	84	47		47
10	0	84		1	1
10	0	75		9	9
9	11	84		1	1
9	8	78		10	10
9	6	67		25	25

No other source mentioned 42-pounders of 10 feet 6 inches, 9 feet 11 inches, or 9 feet 8 inches. Also, when the Committee presented its final report in 1859, the gun of 10-1/2 feet, 84 hundredweight, had vanished; its numbers in use, 47, were included alongside the gun of 9-1/2 feet and 67 hundredweight.[49] It seems likely that the committee had discovered an error and corrected it for the final report.

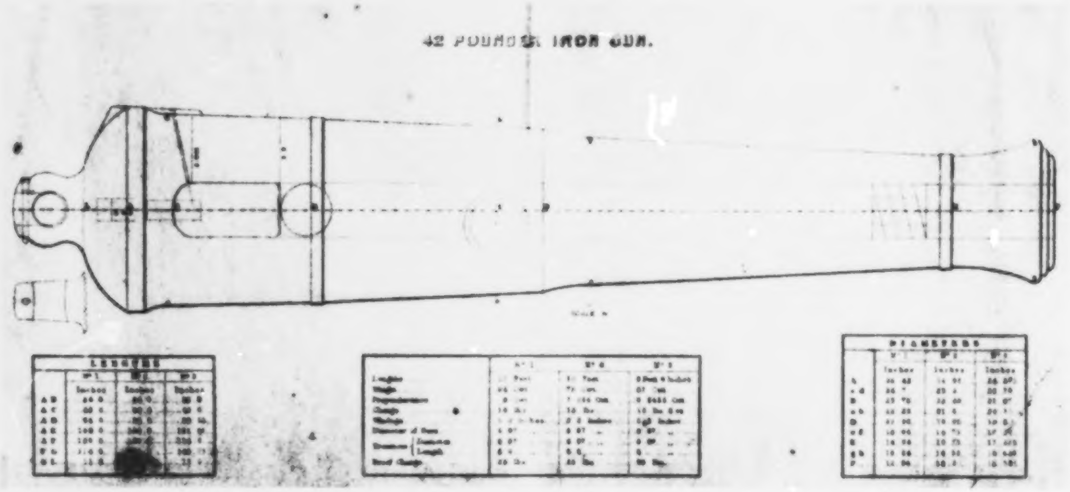


Figure 32. Iron 42-pounder, (1) weight: 84 hundredweight, length: 10 feet, (2) weight: 75 hundredweight, length: 10 feet, (3) weight: 67 hundredweight, length: 9 feet 6 inches, circa 1850. (Boxer, Diagrams of Guns, Plate VI.)

32-Pounder

In the 1720s there were four lengths of cast-iron 32-pounders in service. James listed them in his notebook and gave some details about the gun of 9-1/2 feet.[50]

		Base ring to		Diameters at the				
Length		Trunnion Centre		Base ring		2nd reinforce ring		Weight
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Cwt.
10	0							
9	6	4	1	1	10	1	6 1/4	52
9	0							
8	6							

About 20 years later, the mensuration of 1743 gave detailed dimensions of a 32-pounder of 9-1/2 feet, weighing 5 pounds less than 54 hundredweight.[51] These, with a few slight variations, were reproduced by Adye in his notebook in 1766.[52] A probable example of this gun, raised from the wreck of the Royal George in 1834, is held by the Tower of London.[53]

The establishment promulgated by the Board of Ordnance in 1764 included only one 32-pounder of 9-1/2 feet and weighing 55 hundredweight.[54] Presumably this was the same gun, the detailed dimensions of which Walton put in his notebook in 1780. Except for the increased length of the second reinforce, these measurements were similar, but not identical, to those given by Adye in 1766 and by the mensuration of 1743; the weight, 55 hundredweight, was slightly heavier but identical with that of the establishment of 1764.[55]

Elsewhere in Walton's notebook, in gunnery tables dated 1781, reference to a 32-pounder of 10 feet and 58 hundredweight appeared along with that to the gun of 9-1/2 feet.[56] No other details have been discovered about this gun, but it continued to be referred to into the early nineteenth century, although by then it was probably obsolete. It is likely these were the 32-pounders that Adye recorded in his notebook rather than Blomefield models.[57]

Blomefield's 32-Pounders

By the 1790s, Blomefield had developed his system of construction of iron guns, that initially included only one 32-pounder of 9-1/2 feet and 55-1/2 hundredweight (Fig. 33).[58] This gun, which was designated either for garrison or sea service, proved to be very popular to the end of the smooth-bore era. In 1851, the captain of H.M.S. Excellent, the naval testing laboratory ship, wrote in praise of the gun:

> The old gun has been a great favourite. It works extremely easy, its recoil is not too severe, it does not wear its vent away quickly, its precision is equal to the new A, B, and C guns, which work heavily, and wear the vent away rapidly, and which have reduced windage.[59]

The Committee on Ordnance reported that at the end of March 1857, there were 1961 of these guns in use and 1733 in store; while they did not recommend that it be reproduced, they recognized that it would continue to be in use for a number of years.[60] In 1865 it was ordered retained in service.[61] It seems to have been an excellently designed weapon.

There was also another Blomefield 32-pounder, 8 feet in length and weighing 48 to 50 hundredweight (Fig. 33). It is not known when it was first cast, but Mould noted it in 1825: "Not used in service only six in the Arsenal at Woolwich."[62] Despite its alleged unpopularity in 1825, it remained on the active service list, for many years; in 1859 the Committee on Ordnance recommended that, while it not be manufactured, it continue to be used.[63] In 1865 it was ordered to be retained in service.[64] Details of its construction were published by Boxer and in the Aide-Mémoire.[65] (Care must be taken not to confuse this gun with Millar's model of the same length and weight.)

There were five other Blomefield 32-pounders in service after 1830, but these were bored-up guns (Figs. 33 and 34).[66]

Length Ft.	Weight Cwt.	Bored up From
9	46	24-pdr. of 48 cwt.
8	41	24-pdr. of 43 cwt.
7-1/2	39	24-pdr. of 40 cwt.
6-1/2	32	24-pdr. of 33 cwt.
6	25	18-pdr. of 27 cwt.

The Ordnance began the practice of boring-up about 1830 in an attempt to gain the advantage of heavier shot and shell with reduced windage without incurring the expense of new heavier guns. Although these bored-up guns remained in service for a number of years, the experiment was not successful. The decreased windage did result in greater power of penetration, but the decrease in the weight of the gun meant a more severe recoil, damaging the carriage, rendering the gun unsteady, and therefore making the accuracy of fire more uncertain. If the service charge was reduced to limit the recoil, the power of penetration was lessened, thereby obviating the purpose of boring-up. Also, bored-up guns were unsafe if double-shotted (that is, loaded with two projectiles), a practice common in the naval service.[67] In 1865, it was ordered that the bored-up 32-pounders of 39 and 32 hundredweight were to be retained on the active service list; the others were declared obsolete.[68]

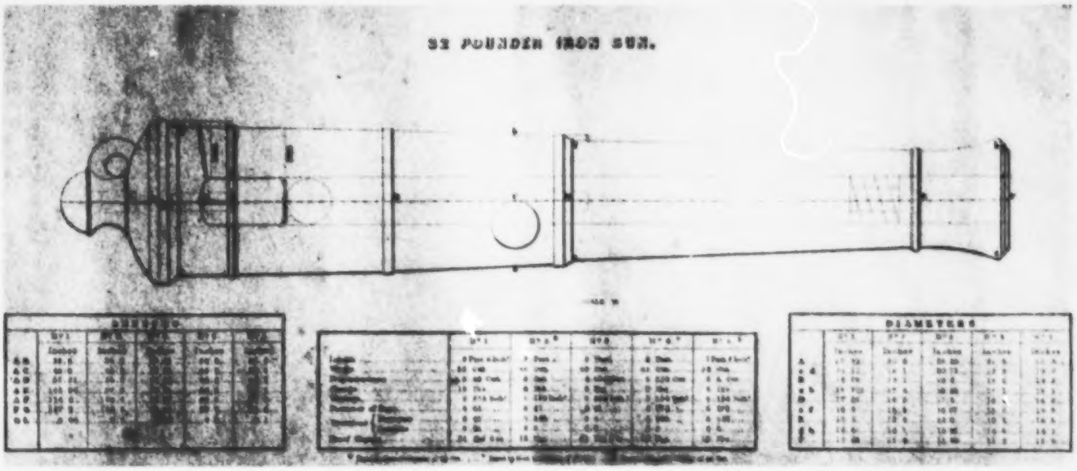


Figure 33. Iron 32-pounder, Blomefield design, (1) weight: 56 hundredweight, length: 9 feet 6 inches, (2) weight: 46 hundredweight, length: 9 feet, (3) weight: 48 hundredweight, length: 8 feet, (4) weight: 41 hundredweight, length: 8 feet, (5) weight: 39 hundredweight, length: 7 feet 6 inches, circa 1850. (Boxer, Diagrams of Guns, Plate VII.)

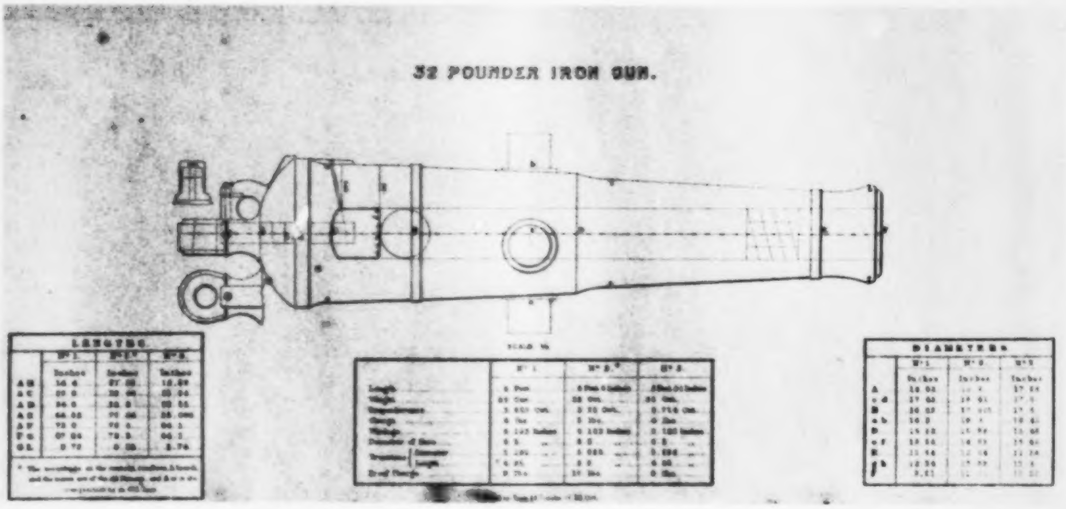


Figure 34. Iron 32-pounder, (1) weight: 25 hundredweight, length: 6 feet, (2) weight: 32 hundredweight, length: 6 feet 6 inches, (3) weight: 25 hundredweight, length: 5 feet 4.1 inches, circa 1850. (Boxer, Diagrams of Guns, Plate X.)

Millar's 32-Pounders

In 1829 or the early 1830s a new set of 32-pounders was developed. Their design has usually been attributed to William Millar, but the name of Sir Alexander Dickson, Wellington's commander of artillery in the Peninsula, has sometimes been attached to two of them. Both men were Inspectors-General of Artillery, Millar succeeding Dickson in 1827. Millar was well known for his successful design of shell guns and of brass field howitzers during the 1820s. He died in 1838 and Dickson in 1840.[69]

There were four varieties of these 32-pounders:

Length Ft.	In.	Weight Cwt.
9	7	63
8	0	48 to 50
6	0	25
5	4	25

According to Miller in his Equipment of Artillery, Millar designed the guns of 9 feet 7 inches and of 6 feet in 1829 (See Fig. 34, Gun No. 1 for the gun of 6 ft.). It seems likely that he designed the other two guns at the same time, although Miller gave no specific date. He did say that two lighter models of the gun of 5 feet 4 inches, weighing 22 and 20 hundredweight, were cast in 1836.[70]

In 1865 when the War Department revised its list of smooth-bore guns in service, it noted: "There are three patterns of 48 cwt. and two of 50 cwt., but issued without distinction." One of these was a Blomefield, but the names of both Millar and Dickson were attached to these guns as well.[71] On the other hand, Strange and Noble, students at the Royal Military Academy, and Miller indicated that Millar designed the 32-pounder of 8 feet and 48 hundredweight.[73] (It had only two muzzle moulding rings rather than three.)[72] Dickson may have designed another gun of 48 or 50 hundredweight. It seems likely that these guns were very similar since they were "issued indiscriminately, mounted on the same carriages, and bracketed together in returns."[74]

The design of the gun of 5 feet 4 inches was attributed to Millar in the early records, but the Committe of Ordnance in the late 1850s indicated that Dickson was the designer, and this attribution was confirmed in the "Changes in Artillery Matériel..." in 1866.[75] Given the paucity of information, it is impossible to account for the change of the designer's name from Millar to Dickson.

In outward appearance the design was quite simple. There were three simple rings (at the breech, first reinforce, and muzzle), a vent patch, and a block behind the base ring for a rear sight, but there were no astragals and fillets. The second reinforce ring and ogee had been eliminated, the second reinforce merging into the chase through a slight curve or cavetto. The two largest guns had a breeching loop with a pin, while the two shortest, in addition, had a horizontal loop which presumably took an elevating screw. This latter arrangement appears to have been based on the carronade design (Fig. 34, Gun No. 3).[76]

A discussion of the strength and weaknesses of Millar guns has not been found, but they seem to have been largely superseded by the new guns of Monk and Dundas. The 32-pounder of 6 feet vanished quickly, but as late as 1857 the two largest guns were still in use.[77] The Committee on Ordnance noted that they would continue in use for some years, and in 1865 they were ordered to be retained on the active list. Only the light piece of 5 feet 4 inches was declared obsolete.[78]

Monk's Medium 32-Pounders (A, B, and C)

The origin of Monk's guns lay in the failure during trials of a number of 32-pounders bored up from 24-pounders of 9 and 6 feet. To replace these guns T.B. Monk brought forward a design for a new 32-pounder. The principle underlying the design, which he had already successfully applied to the construction of a 56-pounder, consisted in maintaining the existing ratio between the weight of metal in the Blomefield 32-pounder and the weight of shot (about 1-3/4 hundredweight to 1 pound),

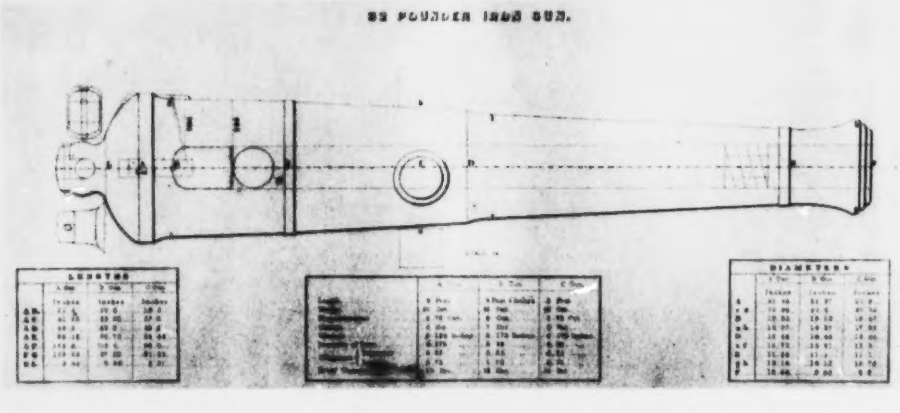


Figure 35. Iron 32-pounder, Monk design, (A) weight: 50 hundredweight, length: 9 feet, (B) weight: 45 hundredweight, length: 8 feet 6 inches, (C) weight: 42 hundredweight, length: 8 feet, *circa* 1850. (Boxer, *Diagrams of Guns*, Plate IX.)

while at the same time redistributing the metal by thickening it around the charging cylinder and diminishing it in the chase. In 1838, Monk successfully brought to trial a 32-pounder of 9 feet and 50 hundredweight (gun A). Shortly thereafter in that year, he applied his method of construction, with some modifications, to two more 32-pounders of 8-1/2 feet and 45 hundredweight and 8 feet and 42 hundredweight (guns B and C) [Figs. 35 and 36.][79]

The three guns were very similar in external appearance to the long Millar 32-pounders. All had three simple rings (at the breech, end of the first reinforce, and muzzle), a vent patch, and a block behind the base ring to take a rear sight, but there were no astragals and fillets. The second reinforce ring and ogee had been eliminated, the second reinforce merging into the chase through a slight curve or cavetto. There was a breeching loop with a pin. Their calibres were less than the old calibre of 32-pounders, 6.41 inches; the gun A had a calibre of 6.375 inches, and guns B and C of 6.35 inches.[80]

Although all three guns were initially intended only for naval service, in 1854 the 50 hundredweight gun was adopted into the land service.[81] It could on occasion be used in the siege train as a substitute for the 24-pounder, and as late as 1881 it was reported to be found occasionally in garrison.[82] In the naval service Monk's guns replaced the old 24- and 18-pounders; although they did not exceed them in range, they had "great advantages over these from the superior magnitude and momentum of their shot."[83] In 1865 the War Department ordered that all three guns be retained in the service.[84]

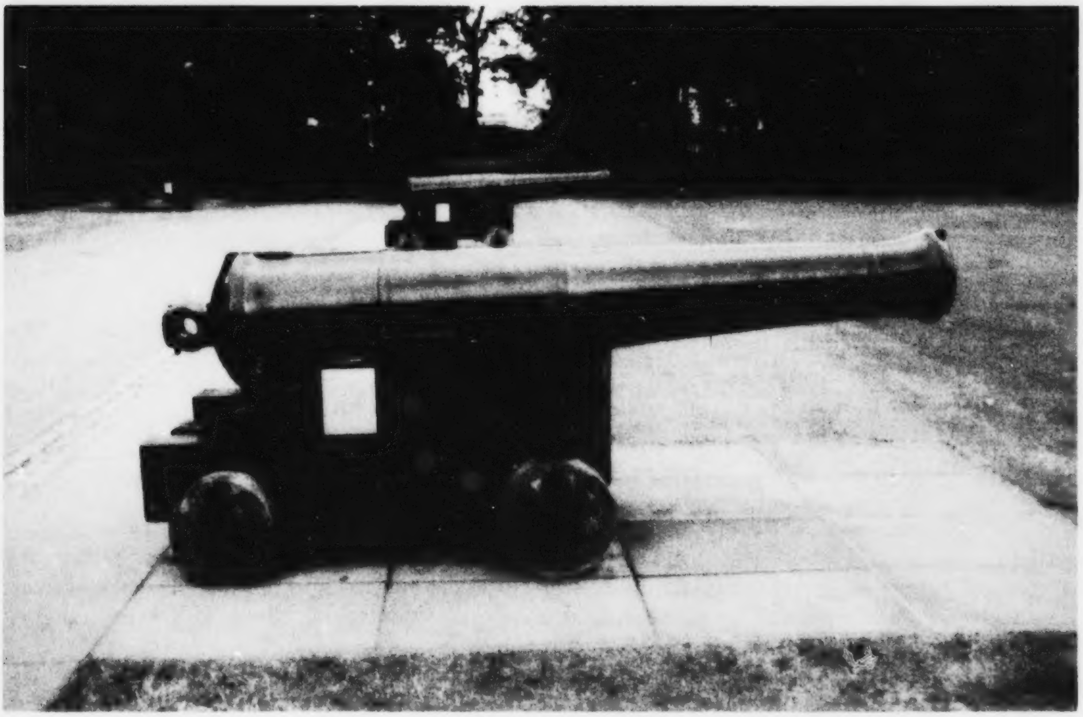


Figure 36. Iron 32-pounder, Monk A, cast by the Walker Company in 1859, weight: 51 hundredweight 2 quarters, length: 9 feet. (National Maritime Museum, London, U.K.)

Dundas' 32-Pounders

Lieutenant-Colonel William Dundas, who was Inspector of Artillery from 1839 to 1852, designed two new 32-pounders which, with Monk's guns, were part of the new armament accepted into the naval service. A short gun of 6 feet and 25 hundredweight dated from 1845. A long gun of 9-1/2 feet and 58 hundredweight was developed in 1847, but it was not officially accepted into service until 1853.

In 1847, Dundas was aware that a new supply of heavy 32-pounders would shortly be required to replenish stores. Until then, the old Blomefield model of 9-1/2 feet and 56 hundredweight had been used, and although its windage of 0.233 inch was perhaps excessive, it was regarded as an excellent gun. Dundas saw the need for new guns as an opportunity to test various constructions and windages to determine which would be best for future service. Because Monk's construction had come under suspicion due to the failure early in 1846 of a 42-pounder of his design, Dundas proposed to submit for trial his own construction of a heavy 32-pounder, along with Monk's and the old Blomefield pattern. A Monk and a Dundas gun were very similar in appearance, the difference being in the distribution of metal, Monk's gun was thicker at the breech in proportion to the thickness at the muzzle face than Dundas'.

Trials were held in 1847, but they seem to have been inconclusive; anyway, no decision was made. Another series of tests was conducted late in 1851 that resulted in 1853 in the adoption of Dundas' gun into the naval service. It was 9 1/2 feet long, weighed 58 hundredweight, and had a calibre of 6.375 inches or a reduced windage of 0.198 inch (Figs. 37 and 38).[85] By 1857, 250 of these guns were mounted on board ship and 99 were in store.[86] In 1861 an ordnance committee recommended that this gun replace the Blomefield 32-pounder of 56 hundredweight in coastal batteries.[87] In 1865, it was included in the list of guns to be retained in service.[88] Later, many of them were converted on the Palliser principle to 64-pounders, RML, land service.[89]

In 1845, Dundas brought forward the design of a light 32-pounder, 6 feet in length, weighing 25 hundredweight, with a calibre of 6.3 inches (windage of 0.123 of an inch).[90] Since a similar gun designed by Millar was already in service, the new gun was probably intended to replace it. It is not known precisely when this gun was

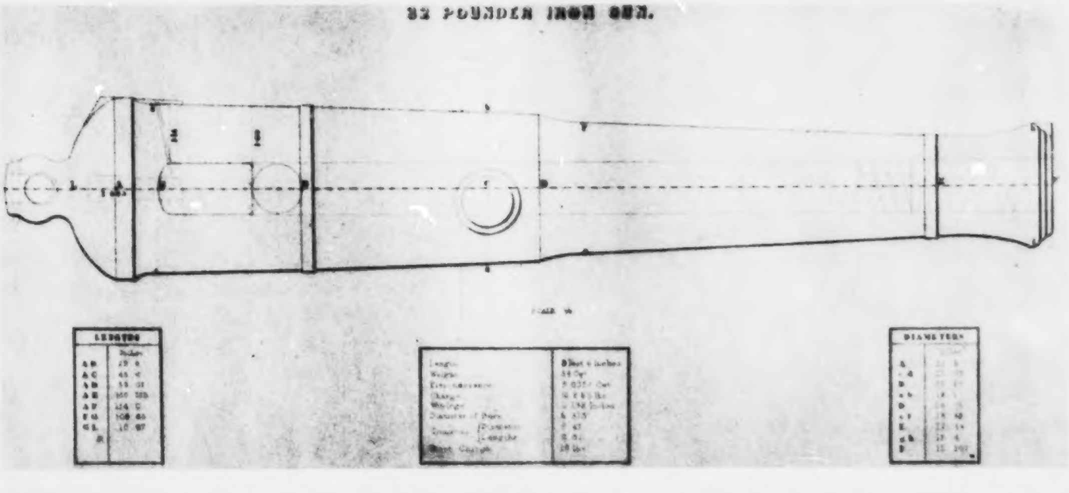


Figure 37. Iron 32-pounder, Dundas design, weight: 58 hundredweight, length: 9 feet 6 inches, circa 1850. (Boxer, Diagrams of Guns, Plate VIII.)

accepted into the naval service, but Douglas, in his Naval Gunnery, included it in a list of guns dated 1848.[91] By 1857, 395 of these guns were mounted on board ship and 527 were in store.[92] In 1865, it was retained on the active list of service ordnance.[93] Although no diagrams of it exist, it probably was similar in appearance to the Dundas 32-pounder of 58 hundredweight, except that it had only two, rather than three, muzzle moulding rings.[94]

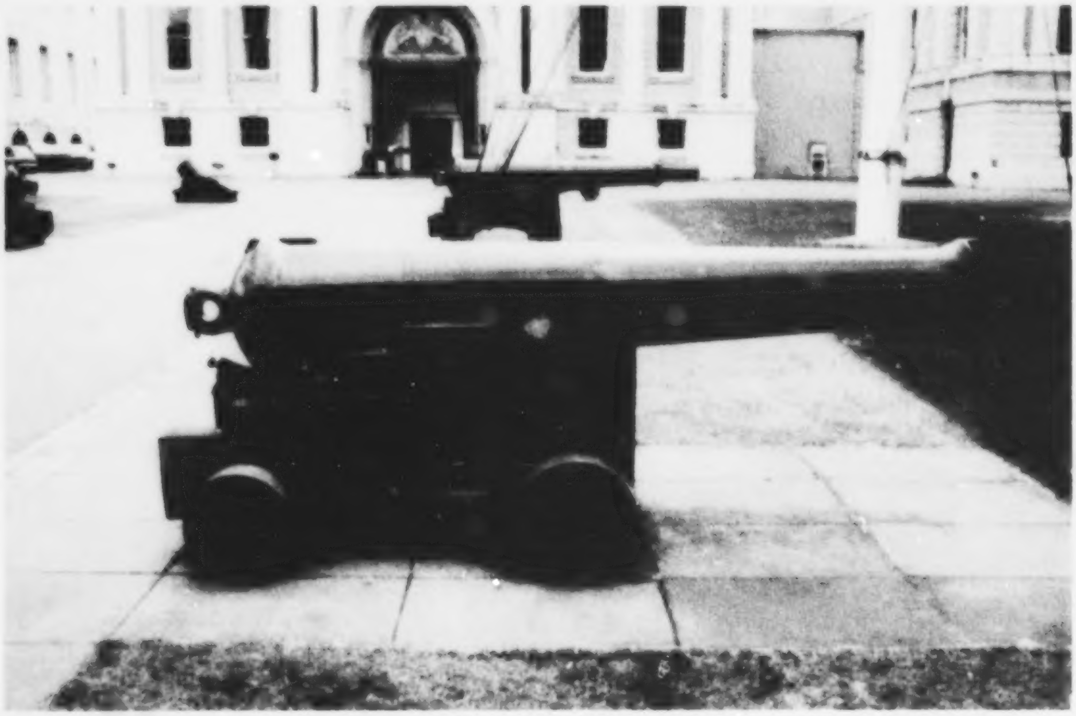


Figure 38. Iron 32-pounder, Dundas design, cast by Low Moor in 1859, weight: 59 hundredweight, length: 9 feet 6 inches. (National Maritime Museum, London, U.K.)

Congreve Guns (32-, 24-, and 18-pounders)

The origin of the Congreve gun lay in a letter from Admiral Hope, one of the Lords Commissioners of the Admiralty, to William Congreve, the younger, in January 1813. With it he enclosed the accounts of a practice that had demonstrated the light 24-pounder of 6-1/2 feet and 33 hundredweight was inadequate to be fired double-shotted, a common naval tactic. Hope suggested that Congreve consider "whether it might not be possible to construct 24-pounders considerably lighter than the long 24-pounders, and which might still be of sufficient weight to be capable of firing two shot." A few days latter Congreve sent the Admiral his plan of a radically designed 24-pounder of 7-1/2 feet and 41 hundredweight.

Congreve determined the weight of his gun by adopting the ratio of weight of shot to weight of gun of the 32-pounder of 55 hundredweight, that is, about 1 to 193. He chose this ratio because this 32-pounder was the standard naval gun of a ship of the line, it was of demonstrated efficiency, and it was quite capable of being fired double-shotted. He rejected the shot-weight ratio of the 42-pounder because he doubted its ability to fire two shots and of the 24-pounder because he felt that it was too heavy.

He also rejected the standard length of 9-1/2 feet. He pointed out that with the increase in the power of modern gunpowder the service charge had been reduced to 1/3 the weight of the shot. With a smaller amount of powder the longer length was no longer necessary to allow for the complete combustion of the service charge. Using tables compiled by the mathematician and ballistics theorist Euler, Congreve arrived at a length of about 15 calibres or 7-1/2 feet which he argued was adequate for a 24-pounder.

Not only was Congreve's gun lighter and shorter than usual, but it was also constucted on a new principle; it appeared to be a hybrid of a gun and a carronade. It was much more conical in shape than a conventional gun, since Congreve had increased the weight of metal at the breech and around the charging cylinder while he had reduced it in the chase. This redistribution of metal, he argued, gave the gun a greater "reacting power," that is, it threw the shot farther than would a conventionally constructed 24-pounder of the same weight. He had arrived at this conclusion seemingly more by intuition than by any scientific principles, although he did cite "the generally received fact of the increased effect in reacting upon, and propelling the charge produced by the thickened breech in fowling pieces and small arms; which I conceive must apply with equal force to ordnance."

Since this increase of weight toward the breech moved the centre of gravity farther back, it was possible to cast the trunnions farther to the rear as well. This allowed the muzzle to project beyond the port of a ship a greater distance than that of a conventional 24-pounder of 8 feet and within 9 inches of the muzzle face of the gun of 9-1/2 feet. The shape of the muzzle was similar to that of a carronade which allowed it to have more traverse without "wooding" against the side of the port. Also, Congreve got rid of the old breeching loop; in his gun the breeching passed through the centre of the neck of the cascable "to equalize the shock of the recoil, and to obviate the blow upon the coin created by the old construction." He also designed a dispart sight cast on the ring in front of the trunnions which allowed the gun to be fired at three elevations, point blank, 2-1/2, and 5 degrees.

Congreve's arguments to Hope convinced the Lords Commissioners of the Admiralty to request the Board of Ordnance to put his theory to the test. Consequently, on 17 February 1813, the Board placed an order with the Carron Company for two sets of 24-pounders constructed on Congreve's principle, one set to be cast with trunnions, the other with a loop like a carronade. They were to be tested against the standard 24-pounder of 9-1/2 feet and 50 hundredweight and two new guns, designed by Blomefield on the old construction, of 7-1/2 and 8 feet and 40 and 43 hundredweight respectively. Sometime between 15 and 22 November 1813 the Board of Ordnance conducted trials of the four guns on Sutton Heath; also, early in October 1813, Congreve's gun had been tested aboard H.M.S. Eurotas. In February 1814, a lighter version of the gun of 7-1/2 feet weighing 37 hundredweight was successfully tested aboard H.M.S. Pactolus. The results were so favourable that 300 more Congreve 24-pounders were ordered to be cast. In 1820, Congreve noted that 700 of his guns had been manufactured, some with trunnions in the axis of the piece, some with trunnions in the lower half of the barrel as usual, and some with loops like a carronade.[95] According to Mould in 1825, these guns were assigned to the "Upper Deck of first rates, quarter deck and Forecastle of 2nd. rates."[96]

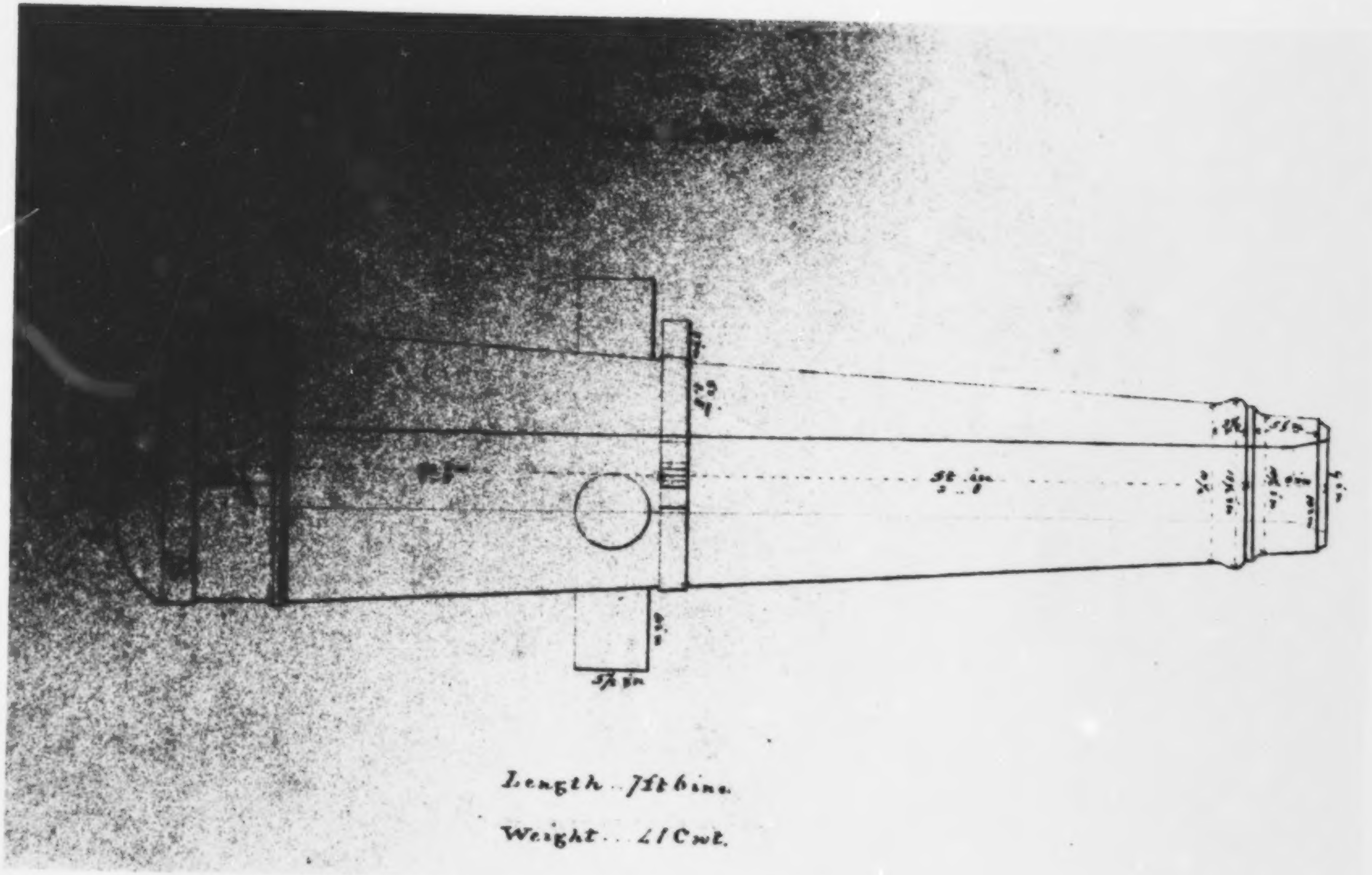

Length 7ft 6ins.
Weight 41 Cwt.

Figure 39. Iron 24-pounder, Congreve design, weight: 41 hundredweight, length: 7 feet 6 inches, circa 1825. (Royal Military College, Mould, p. 104.)

Congreve's hopes for his gun were much too sanguine. By about 1830, the 24-pounders had been withdrawn from service although they were still used by the East India Company.[97] Ironically, an early suggestion of problems had arisen at the end of the Napoleonic wars during an engagement between the *Eurotas*, whose captain had praised Congreve's guns, and the French frigate *Clorinde*. According to Sir Howard Douglas, the Congreve 24-pounders did not perform as well as the French 18-pounders or as well as English long 18-pounders had on other occasions. He conceded that this may have been due partly to a deficiency in British gunnery, but he went on:

> the main defect was in the short 24-pounder guns, which, however they may have succeeded in the experiments at Sheerness (when they *bounded* but a little more than the long 24-pounder against which they were tried), acted most violently on their carriages when heated with continued firing in that protracted action. This is ascribed partly to the greatness of the windage, partly to the charge (one-third of the weight of the shot) being too high, and again, to the diminution of the preponderance of the breech by the trunnions being placed so far back.[98]

Despite these early indications of difficulties, it was not until about 1830 that these guns were removed from service because of "the unsteady and unsafe action of these guns upon their carriages"[99]

The successful trials of his 24-pounders prompted Congreve to propose that other guns be constructed according to his principle:[100]

	Length		Weight
Cal.	Ft.	In.	Cwt.
24 pdr.	8	0	50
32 pdr.	8	3	55
32 pdr.	7	9	50
42 pdr.	not given		
18 pdr.	7	0	31

Evidence of trials of such guns have not come to light, but according to lists of ordnance submitted to the Committee on Ordnance in the late 1850s, other Congreve guns were cast:[101]

	Length		Weight	No. in store,
Cal.	Ft.	In.	Cwt.	1857
24	8	0	not given	1
32	8	3	not given	1
32	7	10	not given	1
18	6	10	not given	8
6	4	9	not given	2

Considering the number of each calibre in existence in 1857, it seems likely that, except the 18-pounder, these guns never went beyond the testing stage. Even the 18-pounder may never have been more than experimental, although six of the eight guns existing in 1857 were in store outside of England.

Despite the dissatisfaction with the 24-pounder Congreve gun the Ordnance bored-up 800 of them to the calibre of a 32-pounder in 1830. According to Sir Howard Douglas, this was an economy measure to attempt to take advantage of heavier weight of shot without incurring the expense of casting new guns.[102] But if the 24-pounder was unsteady in action, surely the bored-up 32-pounder would react even more violently? Whatever the case, the bored-up guns remained on the active list for many years. In 1865 all the Congreve guns, except the 32-pounders, were declared obsolete.[103]

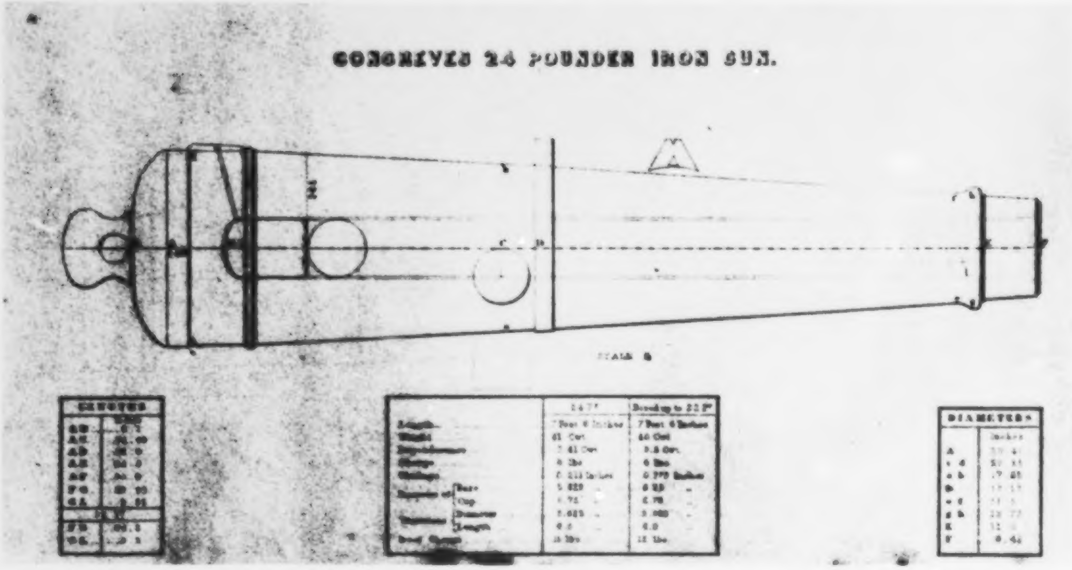


Figure 40. Iron 24- and 32-pounders, Congreve design, (1) weight: 41 hundredweight, length: 7 feet 6 inches, (2) weight: 40 hundredweight, length: 7 feet 6 inches (24-pounder bored up to 32-pounder), circa 1850. (Boxer, Diagrams of Guns, Plate XI.)

24-Pounder

In his notebook in the early 1720s, James set down the lengths of iron 24-pounders - 10, 9-1/2, 9, and 8-1/2 feet -, but gave no other details.[104] Probable examples of the gun of 9-1/2 feet are preserved by Parks on the ramparts of Fort Prince of Wales on Hudson Bay (Fig. 41). These 10 guns, which bear the cypher of King George I, weigh between 48 and 49-3/4 hundredweight. They all have vent patches and the cascable design usually attributed to Armstrong rather than to Borgard. These guns appear to be very similar to the 24-pounder of 9-1/2 feet and slightly more than 49-1/4 hundredweight which was detailed in the mensuration of 1743.[105] In 1766, Adye almost duplicated these dimensions in his notebook; the lengths of the reinforces varied slightly but the diameters, with the exception of those of the trunnions, were the same.[106]

The establishment of 1764 included two iron 24-pounders, but there is some confusion about their lengths - Smith's An Universal Military Dictionary, a list attributed to Congreve, and the Aide-Mémoire indicated that there were two guns of 9-1/2 feet weighing 49 and 47-1/2 hundredweight.[107] On the other hand, Landmann said that the 47-1/2 hundredweight gun was only 9 feet long.[108] It is possible that there were two different weights of the same length of gun, but it seems more likely that an error was made and that the lighter gun was only 9 feet long. In 1780, Walton recorded both lengths and weights, and other sources also referred to them.[109]

In 1780, Walton gave detailed dimensions for both lengths of 24-pounders, but as with the other calibres, the length of the second reinforce was over-long. In another place in his notebook he included a 24-pounder of 10 feet and 52 hundredweight; a practice book of 1780 recorded information on such a gun and it was still listed in Adye's manual as late as 1813, although by then it was likely obsolete.[110] Whether it was a new or an old gun in 1780 is impossible to decide.

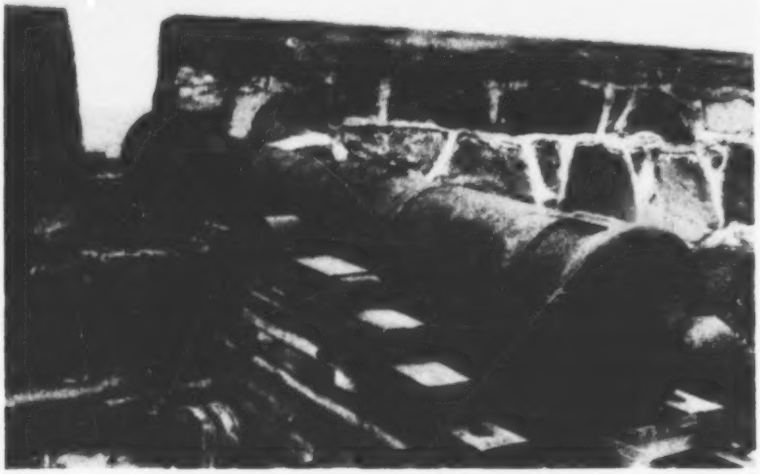


Figure 41. Iron 24-pounder cast in the reign of King George I (1714-27), weight: 49 hundredweight 3 quarters 26 pounds, length: 9 feet 6 inches. (Parks, Fort Prince of Wales National Historic Park.)

As part of his system of construction, Blomefield designed two 24-pounder iron guns of 9-1/2 and 9 feet weighing 50-1/2 and 47-3/4 hundredweight respectively (Fig. 42).[111] Later these were usually referred to as 50 and 48 hundredweight guns.) According to Mould, writing in 1825, the 50 hundredweight gun was used on the

> Middle Deck of First Rates, and Main Deck of some 4th rates,
> also on Fortresses and in Battering Trains.

The 48 hundredweight gun was assigned to the

> Upper Deck of 2nd rates, lower of some 4th rates &c.
> garrisons Battering trains &c.

In the land service the 24-pounder, especially the heavier gun, was highly regarded as a battering piece, and it was extensively used during Wellington's Peninsular campaigns and again in the Crimea some 40 years later.[113] Examples of both these guns can be found within the Parks system.

In 1813, Sir Thomas Blomefield designed two 24-pounders of 8 feet and 43 hundredweight and 7-1/2 feet and 40 hundredweight to be used in the trials on Sutton Health of Sir William Congreve's new medium gun.[114] Neither gun was much used thereafter. In 1825 Mould noted that the gun of 8 feet was "Not used. - 100 in the Arsenal at Woolwich."[115] Spearman included it in his manual of 1828, but thereafter it went unnoticed until it was officially declared obsolete in 1865.[116] In 1825, the gun of 7-1/2 feet was "Appropriated to the Upper Deck of one Ship only; the Donegal."[117] It too was officially declared obsolete in 1865.[118]

A short 24-pounder of 6-1/2 feet and 33 hundredweight, undoubtedly a Blomefield design, was first cast in 1805.[119] As a 24-pounder it proved unsuccessful; in 1825 Mould wrote that it was not used.[120] Despite this, Boxer included it in his series of gun diagrams in the 1850s and Miller described it in his *Equipment of Artillery* in 1864 (Fig. 43).[121] It was declared obsolete in 1865.[122] It did have a separate life as a 32-pounder, bored-up to the higher calibre probably in 1830.[123]

There are records of 24-pounders of 6 feet, presumably of Blomefield construction, being proofed at Woolwich in the period from March 1800 to June 1801. Some were cast with chambers, the presence of which in guns was unusual.[124] In 1825, Mould noted that the 24-pounder of 6 feet and 30 hundredweight, probably the same gun, was "not used at present."[125] Thereafter no references to this length and weight of 24-pounder have been found.

Although Blomefield had designed a 24-pounder of 8 feet in 1813, the Ordnance bored-up a number of Blomefeld 18-pounders of that length and 38 hundredweight. This gun, weighing 37 hundredweight in its new calibre, was first noted in a list of service ordnance of 1847, but it is impossible to say when it was first converted.[126] The *Aide-Mémoire* included it in its table of dimensions in 1853, but four years later only nine of these weapons still existed.[127] Thereafter they were not not discussed.

As well as the 18-pounder of 8 feet, 12-pounders of 6 feet and 21 and 24 hundredweight were bored-up to 24-pounders of 20 and 22 hundredweight.[128] These pieces were used in casemates and flank defences in substitution for the 24-pounder carronade.[129] In 1865, it was decided to retain this gun, along with its larger sisters of 50 and 48 hundredweight, on active service.[130]

There also appear to have been some very obscure 24-pounders. The dimensions of two of these, designated Millar constructions, were set out in the tables in the *Aide-Mémoire* in 1853; they were 7-1/2 and 6-1/2 feet long and weighed 41 and 33 hundredweight respectively.[136] Their dimensions were very similar to the old

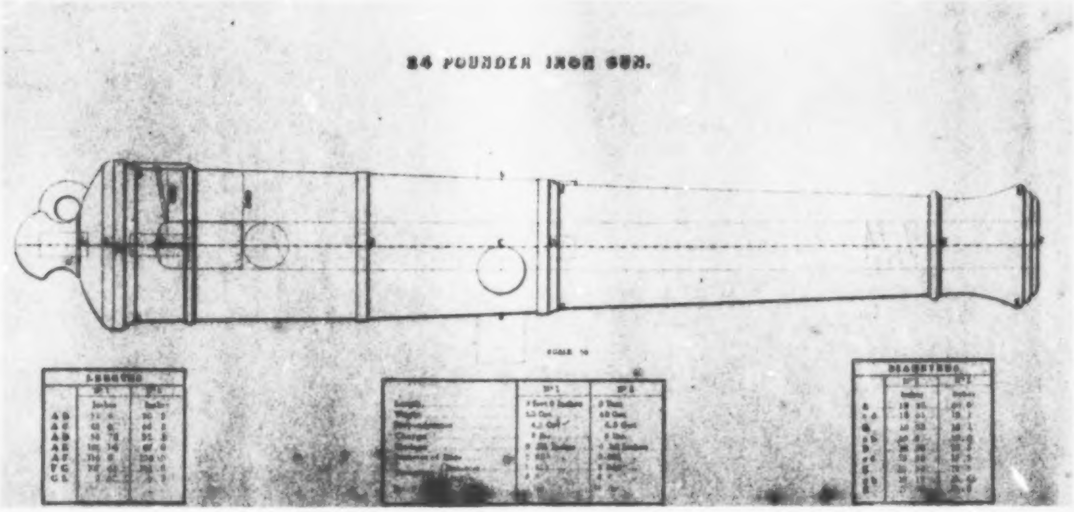


Figure 42. Iron 24-pounder, Blomefield design, (1) weight: 50 hundredweight, length: 9 feet 6 inches, (2) weight: 48 hundredweight, length: 9 feet, *circa* 1850. (Boxer, *Diagrams of Guns*, Plate XII.)

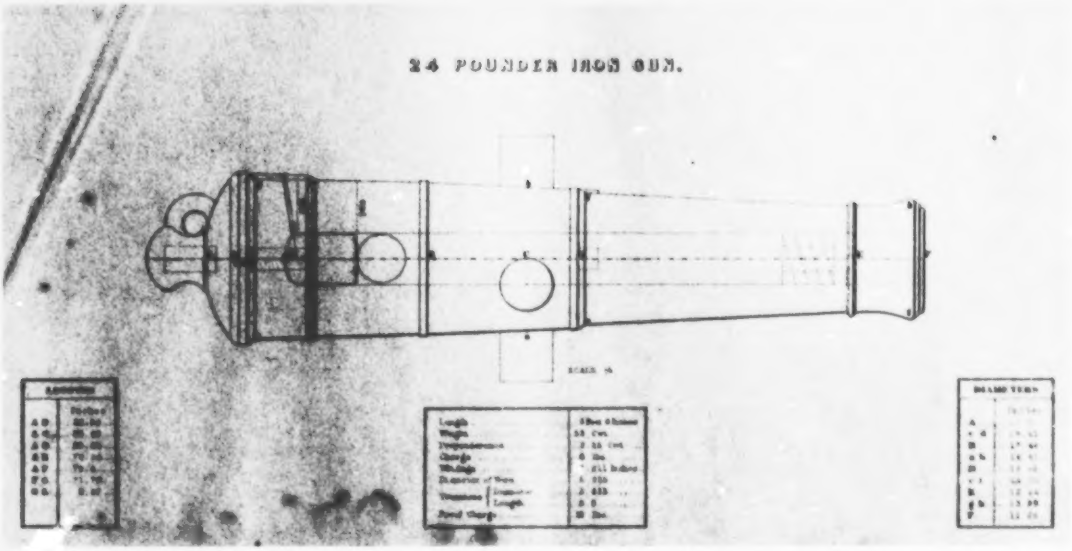


Figure 43. Iron 24-pounder, Blomefield design, weight: 33 hundredweight, length: 6 feet 6 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XIII.)

Blomefield pattern, but the calibre was slightly less, 5.792 instead of 5.823 inches. Presumably they had the profiles of other Millar guns.

In the records of the Committee on Ordnance, 1857-9, they were a number of 24-pounders designated "N.P." for new pattern; these included guns of 7-1/2 and 6-1/2 feet, but also of 9-1/2, 9, 8, and 6 feet. Unfortunately, there were no other details.[137] None of these guns appeared in the lists of 1865 when the War Department decided which guns were to be retained and which were to be declared obsolete.

Finally, the Committee on Ordnance recorded a short 24-pounder, 4 feet 10 inches in length and weighing 18 hundredweight, designated "Dickson's," presumably designed by Sir Alexander Dickson.[133] In 1865, the War Department declared obsolete a 24-pounder of the same weight but said to be 5 feet in length, also described "Dickson."[134] Presumably these were the same guns.

18-Pounder

According to James, there were six iron 18-pounders in service in the early 1720s. They varied in length by 6 inches from 11 to 8-1/2 feet. The only other detail that he noted was that for the gun of 11 feet the distance from the centre of the trunnions to the base ring was 4 feet 9 inches.[135] Although it is impossible to be certain, these guns may be similar in design to an 18-pounder, depicted in a diagram, circa 1735, which was 9 feet long and weighed 41 hundredweight 1 quarter 8 pounds (Fig. 44).[136] Its dimensions were very similar to those given by the mensuration of 1743 and by Adye in his notebook in 1766.[137] There were slight variations in the

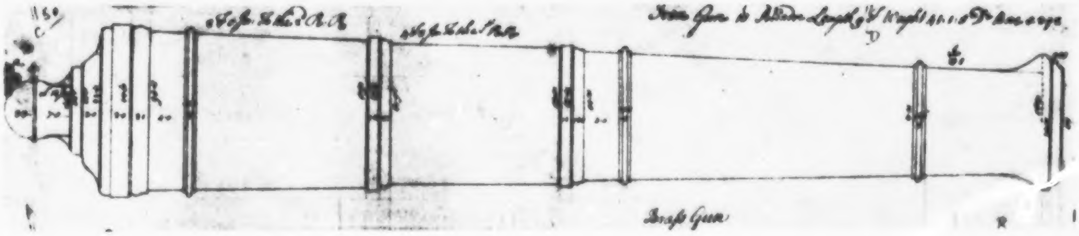


Figure 44. Iron 18-pounder, weight: 41 hundredweight 1 quarter 8 pounds, length: 9 feet. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

three sets of dimensions, but essentially they were of the same weapon; indeed, the weights given on the drawing and of the gun of 1743 were indentical, 41 hundredweight 1 quarter 8 pounds.

At Mahon in Minorca in 1745, General George Williamson and other artillery officers conducted tests to attempt to determine the best length for an 18-pounder and the proper charge for the greatest range. They used two types: one was 11 feet long and weighed 51 hundredweight 5 pounds, the other 9 feet long and 39 hundredweight 1 quarter 3 pounds.[138] Although slightly light, the latter gun was probably that depicted in the circa 1735 drawing and the 1743 mensuration. Three examples of an 18-pounder from the reign of King George II (1727-60), all about 9 feet long, one of which weighs 41 hundredweight 2 quarters 10 pounds, lie on the site of an old battery at the Gut of Digby in Nova Scotia (Fig. 45). They bear a close resemblance to the circa 1735 gun.

Figure 45. Three iron 18-pounders, cast in the reign of King George II (1727-60), weight: 41 hundredweight, length: 9 feet. (Parks Gut of Digby, Nova Scotia.)

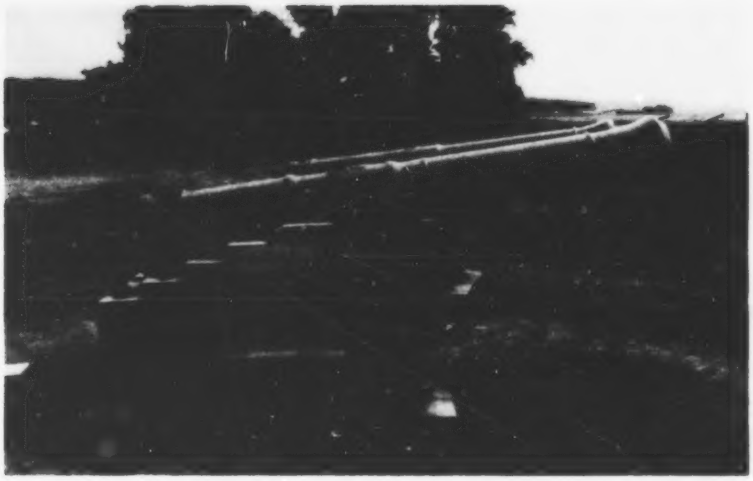


Figure 46. Iron 18-pounder, cast in the reign of King George III (1760-1820), weight: 41 hundredweight 2 quarters 21 pounds, length: 9 feet. (Parks, Fort Anne National Historic Park.)

Although the gun of 11 feet was not mentioned in the offical establishment after the 1720s, it may have had a long history. In 1820, at York, Upper Canada, an unnamed person who wanted to establish a forge at the Credit River made inquiries "...about the purchase of the unserviceable Iron Ordnance lying about on the beach." These guns included 6 iron 18-pounders varying in weight from about 50 to about 54 1/4 hundredweight.[139] An obvious inference is that they were old 18-pounders of 11 feet. It is impossible to know how long they had been "on the beach," but possibly they had seen service during the War of 1812. Indeed, two 18-pounder guns, condemned and lacking trunnions, were pressed into service to defend York against the American attack in April 1813.[140] As late as 1857, an 18-pounder, 11 feet long, "O.P." (old pattern) turned up in the lists of guns submitted to the Committee on Ordnance.[141] It is not known precisely what was meant by "O.P."

The establishment of 1764 listed only one 18-pounder, a gun of 9 feet and 40 hundredweight (Fig. 46).[142] In 1780, Walton included an 18-pounder of this length and weight in his table of dimensions.[143] With the usual aberration of the length of the second reinforce, these dimensions were very similar to those of 1743 and Adye's of 1766. Elsewhere in his notebook he referred to an 18-pounder of 9-1/2 feet and 42 hundredweight; such a gun was used in practices in 1780.[144] These two lengths were probably the standard 18-pounders of the period. Adye included both guns in his manuals of 1801 and 1813, but by then they were probably being superseded by the newer Blomefield constructions.[145]

As part of his system of guns, Blomefield designed two 18-pounders of 9 and 8 feet, weighing 42-1/2 and 37-3/4 hundredweight respectively (Fig. 47).[146] It is not known precisely when these guns came into service, but there are records of 18-pounders of 9 and 8 feet, which were probably Blomefield guns, being proofed at Woolwich in 1801.[147] In 1825, Mould noted that the gun of 9 feet was used on the "Upper Deck 74 Gun Ships, Garrison and Battering trains"; the gun of 8 feet was assigned to the "Main Deck 46 and 42 Gun Frigates Garrison Battering train." He also mentioned an 18-pounder of 6 feet and 27 hundredweight that was "not used at present."[148] Presumably this was also a Blomefield gun.

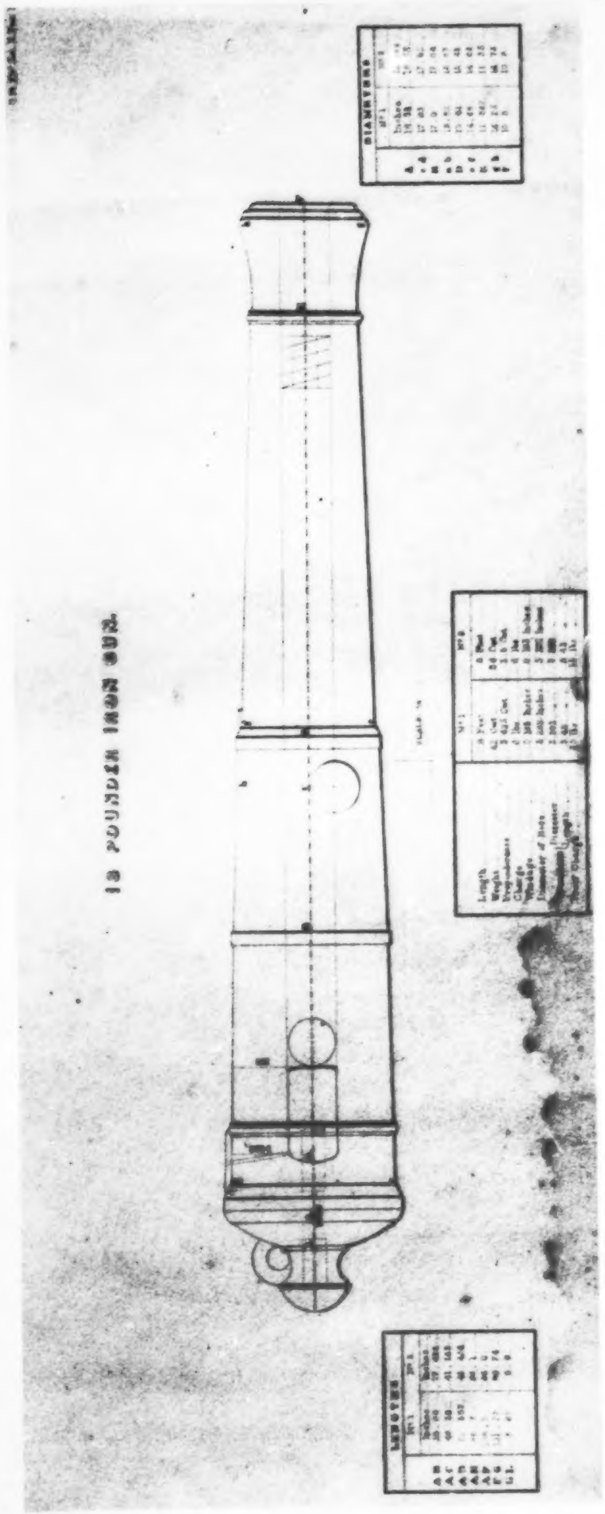

18 POUNDER IRON GUN.
DIAMETERS
LENGTHS

Figure 47. Iron 18-pounder, Blomefield design, (1) weight: 42 hundredweight, length: 9 feet, (2) weight: 38 hundredweight, length: 8 feet, circa 1850. (Boxer, Diagrams of Guns, Plate XIV.)

The 18-pounders of 9 and 8 feet continued in service into the 1860s, but also three light 18-pounders, bored-up from smaller calibres, appeared on the active list in the 1840s:[149]

Length Ft.	Weight Cwt.	Bored-up From
7	22	9 pdr. of 24 cwt.
6	20	12 pdr. of 22 cwt.
5-1/2	15	9 pdr. of 17 cwt.

Initially it was assumed that these were Blomefield patterns, the gun of 7 feet being general service and the other two being old land service models, with some exterior machining when they were bored up. Unfortunately, the various sources are in disagreement. The detailed dimensions given by Boxer (Fig. 48) and in the Aide-Mémoire do not agree. Also, according to the "Changes in Artillery Materiel..." approved in 1865, the two smallest guns were designed by Dickson.[150] At present, it has been impossible to reconcile or clarify the conflicting evidence.

In 1865, four 18-pounders were placed in the list of guns to be retained in service:

Length Ft.	Weight Cwt.	Remarks
9	42	Blomefield
8	38	Blomefield
6	20	Dickson
5 1/2	15	Dickson

Also, four 18-pounders were placed in the list of guns to be abolished:

Length		Weight
Ft.	In.	Cwt.
9	0	40
6	10	32
6	0	27
7	0	22

These guns were all identified as Blomefield's but there may be an error here.[151] The gun of 7 feet must be the bored-up 9 pounder. The gun of 6 feet 10 inches has elsewhere been identified as a Congreve gun (see section on Congreve guns). The gun of 6 feet was an old Blomefield model (see above). The gun of 9 feet and 40 hundredweight remains a mystery.

12-Pounder

In his notebook in the 1720s James listed four iron 12-pounders varying in length, by 6 inches, from 10 to 8-1/2 feet. Unfortunately, he gave no other details.[152] It seems likely that Parks has preserved a number of these guns at Fort

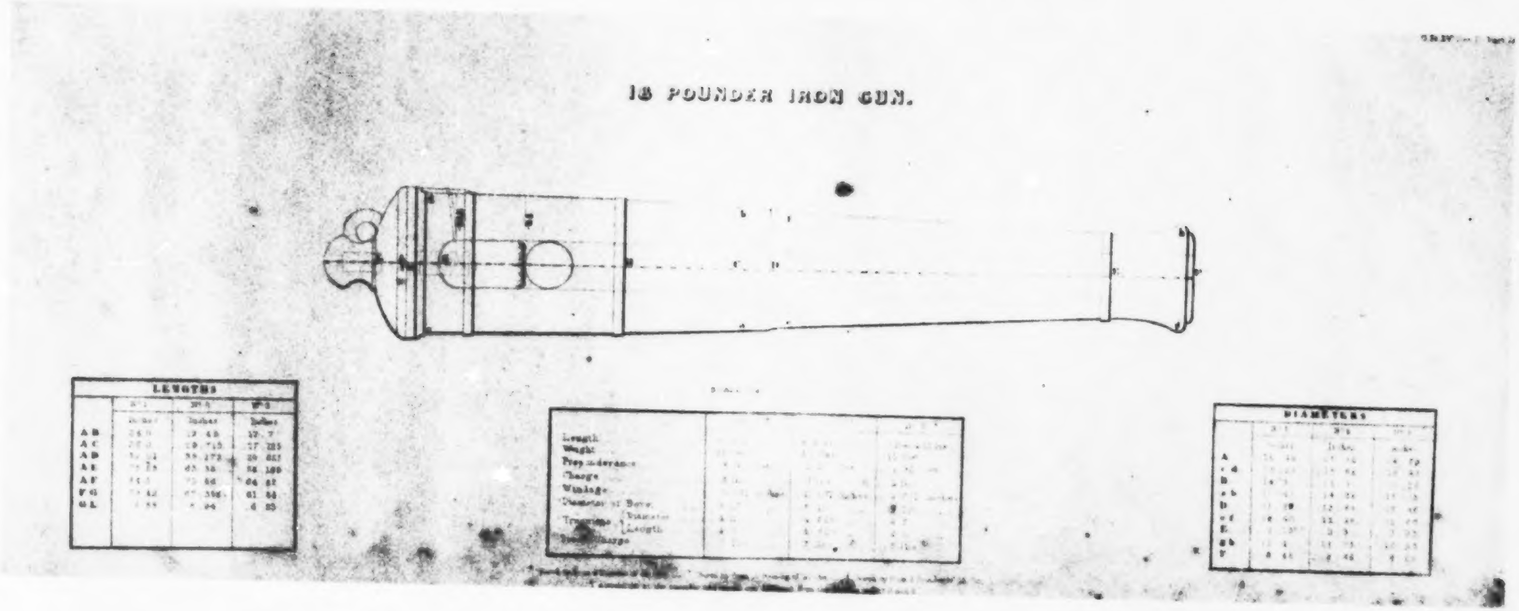

18 POUNDER IRON GUN.
LENGTHS
Inches
Inches
Inches
Length
Weight
Preponderance
Charge
Windage
Diameter of Bore
Trunnions
Diameter
Length
DIAMETERS

Figure 48. Iron 18-pounder (bored-up), (1) weight: 22 hundredweight, length: 7 feet, (2) weight: 20 hundredweight, length: 6 feet, (3) weight: 15 hundredweight, length: 5 feet 4.82 inches, circa 1850. (Boxer, Diagrams of Guns Plate XV.)

Prince of Wales at the mouth of the Churchill River on Hudson Bay. Damaged by the French when they captured the fort in 1782, 24 iron 12-pounders, cast in the reigns of Queen Anne and King George I, still point their muzzles out through the embrasures of the fort. Six of these, each 9 feet long and weighing from 32-1/4 to 33-1/4 hundredweight, bear the Rose and Crown of Queen Anne (Fig. 49). Of the remaining, 12 are from the reign of King George I (Fig. 50); six others are without insignia, but since they have been cast with a vent patch they too are probably Georgian. Of these 18 guns, three are 9-1/2 feet long, weighing from 33-1/2 to 35 hundredweight; 14 are 9 feet long, weighing from 32 to 33-1/2 hundredweight; one is 8 feet long and weighs almost 33 1/4 hundredweight. The only obvious difference in design is the shape of the cascable, the Queen Anne guns differing from the others.

The mensuration of 1743, the first detailed table of dimensions discovered, gave the weight of an iron 12-pounder as 32 cwt. 2 qr. 3 lb., a weight similar to the Georgian 9-foot guns at Fort Prince of Wales.[153] Until detailed measurements can be taken of the guns at the fort, it is impossible to say if any changes had occurred after the accession of King George II in 1727. The dimensions of 1743 were almost identical to those given for a 12-pounder of 9 feet in Adye's notebook of 1766, so similar that it is difficult not to conclude that they were for the same gun.[154] In 1780 Walton put down detailed measurements for a 12-pounder of 9 feet, which were also quite similar, but the chase had a greater thickness suggesting that some changes in design had been made.[155]

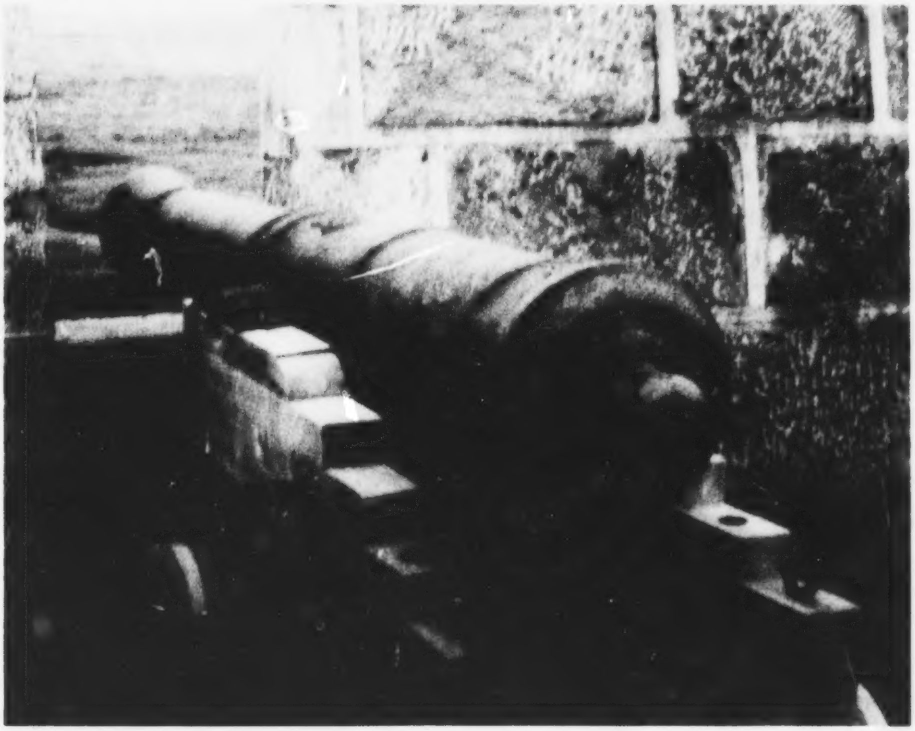


Figure 49. Iron 12-pounder, cast in the reign of Queen Anne (1702-14), weight: 33 hundredweight 5 pounds, length: 9 feet. (Parks, Fort Prince of Wales National Historic Park.)

If changes in specifications were made, perhaps they occurred in 1764 when the Board of Ordnance established three lengths and weights of 12-pounder iron guns:[156]

Length Ft.	Weight Cwt.
9	32 1/2
8 1/2	31 1/2
7 1/2	29 1/4

In 1780 Walton gave a table of detailed dimensions for iron 12-pounders of these lengths and weights. Elsewhere in his notebook he also mentioned a 12-pounder of 9 1/2 feet and 34 hundredweight, but it is not clear whether this was an old or new gun. Except for the consistent aberration of the length of the second reinforce, the dimensions given by Walton approach very closely those attributed to Armstrong's construction as set down in Landmann's notes on artillery.[157]

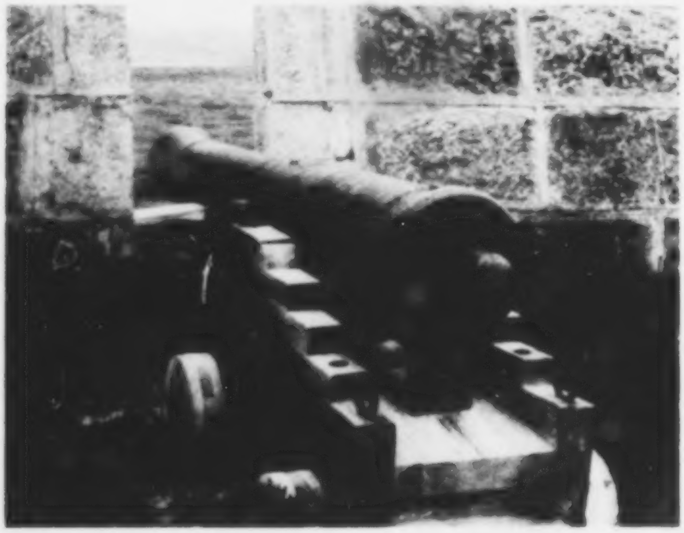


Figure 50. Iron 12-pounder, cast in the reign of King George I (1714-27), weight: 32 hundredweight 1 quarter, length: 9 feet. (Parks, Fort Prince of Wales National Historic Park.)

Armstrong's construction was replaced by Blomefield's in the late 1780s or 1790s. Although the appearance and thickness of metal changed, the Blomefield 12-pounders for sea and garrison service remained the same length, although two of them were heavier:

Length Ft.	Weight Cwt.	
9	34-3/4	
8-1/2	33-1/4	
7-1/2	29-1/4	(Fig. 51)

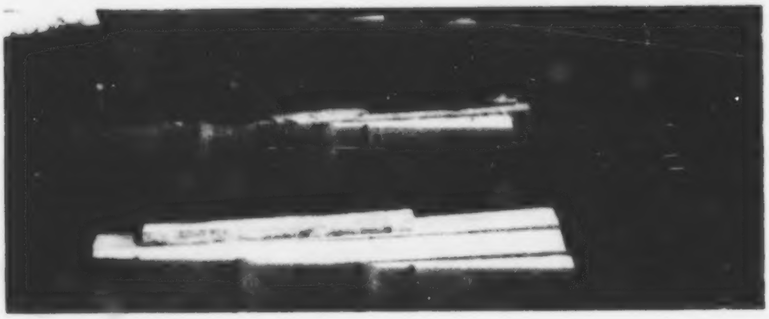


Figure 51. Iron 12-pounder, cast during the reign of King George III (1760-1820), weight: 29 hundredweight 22 pounds, length: 7 feet 6 inches. The trunnions have been knocked off. (Parks, York Redoubt, Halifax Defence Complex.)

As well, Blomefield designed two short guns exclusively for the land service, both 6 feet long and weighing 24 and 21 hundredweight respectively.[158] The latter lacked the breeching loop of the general service gun and their muzzles were shaped differently (Fig. 52).[159]

In 1825, Mould provided a brief resumé of the uses of these 12-pounders:[160]

Length Ft.	Weight Cwt.		Use
9	34		- chase guns, line of battle ships, garrison
8-1/2	33		- garrison service, battering train
7-1/2	29		- quarter deck, line of battle ships, garrison
6	28	[sic]	- not used at present

It is presumed that Mould made an error in writing the weight of the 6-foot gun; probably he was referring to the 24 hundredweight gun, although this is by no means clear. The 21 and 24 hundredweight guns were bored-up to a 24-pounders of 20 and 22 hundredweight (See section on 24-pounder).

With the development of new and heavier guns in the 1830s and '40s, the usefulness of 12-pounders was clearly limited. By the mid-1840s their use was becoming exceptional. The ordnance committee of 1844 recommended that the 9-foot gun of 34 hundredweight be substituted occasionally for the 18-pounder in batteries where quick fire might be necessary against storming parties or boat attacks. The 8-1/2 foot, 33 cwt. gun, was recommended for use sometimes with the siege train since it was powerful enough to dismount artillery and required less ammunition (presumably meaning powder) than an 18- or 24-pounder gun.[161] By 1857, except for some of the 12-pounders of 6 feet, all of these guns were in storage, either in England or abroad.[162]

Length Ft.	Weight Cwt.	Mounted England	Mounted Abroad	In store England	In store Abroad	Total
9	34			257	53	310
8 1/2	33				82	82
7 1/2	29 1/2			321	61	382
6	21	194	232	218	9	653
4	?				1	2

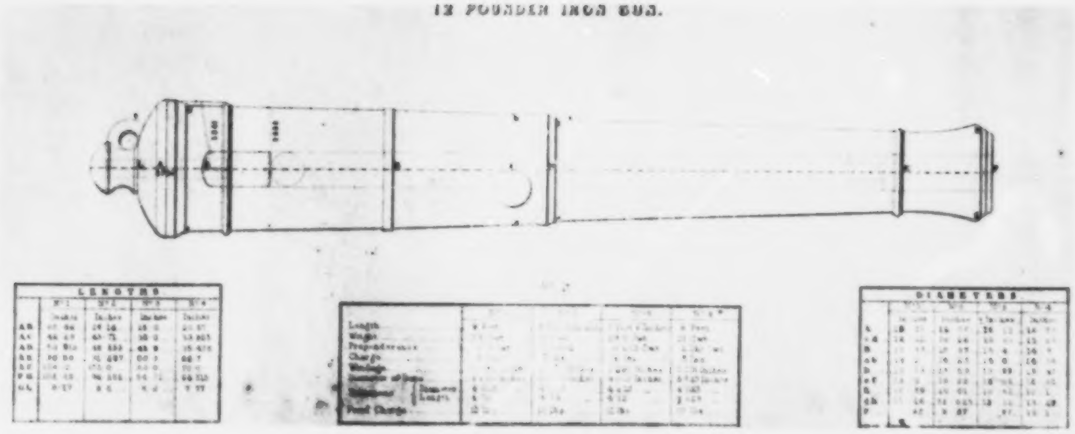


Figure 52. Iron 12-pounder, (1) weight: 34 hundredweight, length: 9 feet, (2) weight: 33 hundredweight, length: 8 feet 6 inches, (3) weight: 29.5 hundredweight, length: 7 feet 6 inches, (4) weight: 21 hundredweight, length: 6 feet, circa 1850. (Boxer, Diagrams of Guns, Plate XVI.)

Presumably the 21 hundredweight gun was used for the defence of ditches or other places where range was not important. The Committee on Ordnance, which reported in 1859, recommended that all but the 12-pounder of 6 feet be declared obsolete and disposed of, but in 1865 the guns of 9 and 8-1/2 feet were ordered retained in service and the remainder were declared obsolete.[163]

9-Pounder

Two 9-pounders from the reign of Queen Anne (1702-14), both 9 feet long and weighing about 21-1/2 hundredweight, can be seen in the Tower of London (Fig. 53).[164] Although no detailed measurements have been taken, their proportions, ornamentation, and cascable design appear to be the same as those of a 6-pounder drawn by Borgard in 1716 (see below).[165] It is impossible to know if this design remained unchanged for the four 9-pounders that James listed in his notebook in the early 1720s, because he gave only their lengths which varied by 6 inches from 10 feet to 8 feet 6 inches.[166] Thereafter, a detailed drawing, circa 1735 (Fig. 54), and tables of dimensions from 1743 and 1766 of a 9-pounder of 8 feet 6 inches, weighting 27-3/4 hundredweight, were so similar that they must have been of the same gun.[167]

In 1764, the Board of Ordnance, as part of the establishment of artillery pieces, ordered that there were to be five lengths and weights of 9-pounders:[168]

Length Ft.	**Weight** Cwt.
9	29
8 1/2	27 1/2
8	26 1/2
7 1/2	24 1/2
7	23

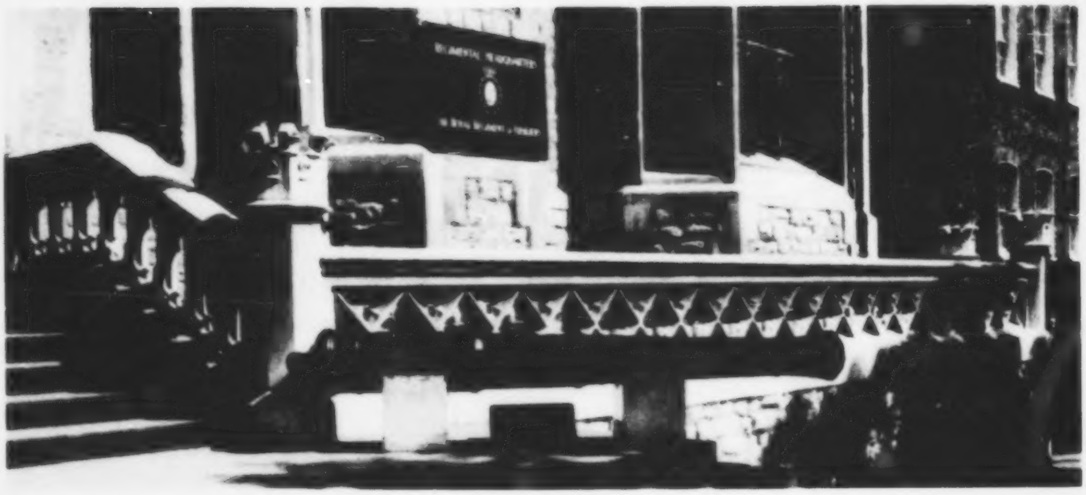


Figure 53. Iron 9-pounder, cast in the reign of Queen Anne (1702-14), weight: 21 hundredweight, length: 9 feet. (Collection of the Armouries, H.M. Tower of London. Reproduced by kind permission of the Trustees of the Armouries. See Blackmore, p. 70.)

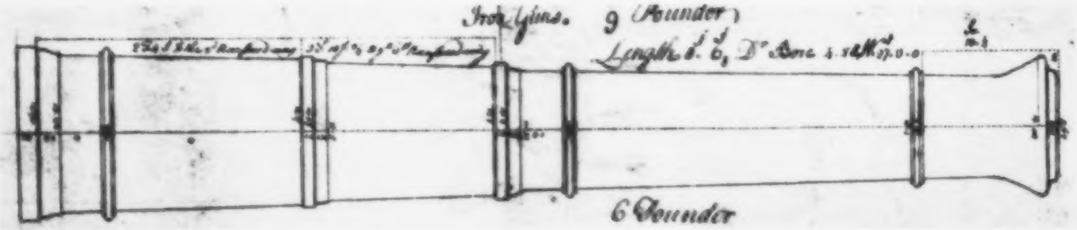


Figure 54. Iron 9-pounder, weight: 27 hundredweight 3 quarters, length: 8 feet 6 inches. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

In a table dated 1780, Walton gave detailed dimensions of only three 9-pounders, of 8-1/2, 7-1/2, and 7 feet; the weights of the latter two guns were the same as the establishment, but that of the gun of 8-1/2 feet was a hundredweight lighter. Except for the usual aberration of the length of the second reinforce, the dimensions of the gun of 8-1/2 feet were very similar, but not identical, to the dimensions of circa 1735, 1743, and 1766.[169] Elsewhere in his notebook, under the date of 1781, Walton included a list of 9-pounders which matched the establishment of 1764, but with the addition of a gun of 9-1/2 feet, weighing 30-1/4 hundredweight.[170] Whether this gun was an old or new weapon was not clear.

In the mid-1780s or early 1790s, Blomefield produced specifications for his design of 9-pounders, four of which were for garrison and sea service and the fifth exclusively for land service.[171]

Length Ft.	Weight Cwt.	Services
9	31	
8 1/2	29 1/2	
7 1/2	26 1/2	
7	25 1/4	sea service and garrison
5 1/2	18	land service

It is impossible to say how quickly these guns were introduced - Adye in 1801 and 1813 included only two 9-pounders in his manual, both probably of the old construction, one of 7-1/2 feet weighing 24-1/2 hundredweight and the other of 7 feet weighing 23 hundredweight.[172]

Undoubledly the new guns were introduced before 1815; they were certainly in use by the 1820s. In 1825, Mould gave a capsule review of them:[173]

Length Ft.	Weight Cwt.	Services
9	31	garrison
8 1/2	29	garrison
7 1/2	26	chase guns of frigates, garrison
7	25	garrison
5 1/2	22	not used

It is possible that a heavier gun of 5-1/2 feet had been introduced, but more likely the weight given by Mould was an error since all subsequent reference to this gun gave its weight as either 17 or 18 hundredweight.

The design of the 9-pounder followed the standard Blomefield pattern, as shown in the Boxer drawing of 1853, except for the land service gun of 5 1/2 feet (Fig. 55).

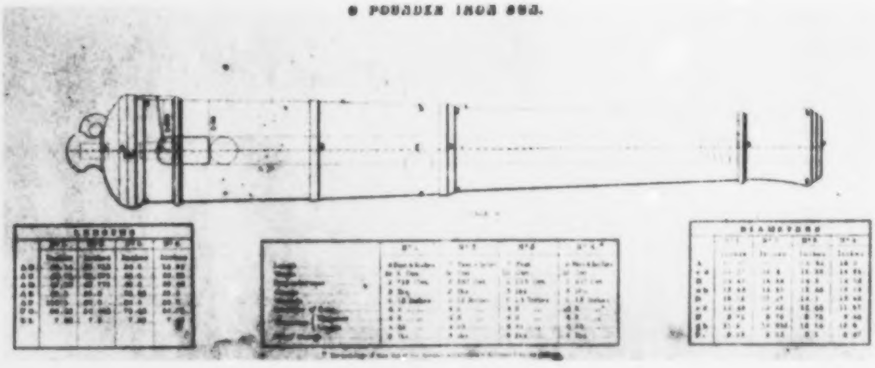


Figure 55. Iron 9-pounder, Blomefield design, (1) weight: 28.5 hundredweight, length: 8 feet 6 inches, (2) weight: 26 hundredweight, length: 7 feet 6 inches, (3) weight: 25 hundredweight, length: 7 feet, (4) weight: 18 hundredweight, length: 5 feet 6 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XVIII.)

According to a footnote, "The mouldings of this Gun at the cascable and muzzle are different from the drawing."[174] Presumably it resembled its sister land service 12-pounder. The cascable lacked the breeching loop and took the form of an ogee; the muzzle was without two of the three rings (see 12-pounder above).

Even the larger 9-pounders were probably little used. No reference can be found to the gun of 9 feet after 1840. According to a student at the Royal Military Academy in 1845, "Nine and six Prs. (iron) are now little used except sometimes for saluting."[175] The Committee on Ordnance which met in the late 1850s revealed that there were large numbers of these weapons in store in England or abroad, but only 111 of the gun of 7-1/2 feet and 26 hundredweight were actually in use.[176] In 1864, according to Millar, 9-pounders "may occasionally be found in the flanks of old fortifications, but their ordinary use is confined to firing salutes...."[177] The Committee on Ordnance recommended that all but the gun of 7-1/2 feet be declared obsolete and disposed of; it recognized that the latter would stay in use, but it was not to be replaced.[178] In 1865, it was ordered that the guns of 8-1/2 and 7 feet be retained in service and that those of 7-1/2 and 5-1/2 feet be declared obsolete.[179]

6-Pounder

Albert Borgard has left a 1716 scale drawing of an iron 6-pounder, 8 feet long, with dimensions calculated both in inches and in calibres (Fig. 56). He did not write out a formula for computing the lengths of the component parts, but it appears to be the following

first reinforce: 2/7 of total length
second reinforce: 1/7 of total length + 1-1/2 calibres
chase: 4/7 of total length - 1-1/2 calibres
from rear of base ring to trunnion centre: 3/7 of total length

This formula and the thickness of metal computed by Borgard in calibres may be used, presumably, to reconstruct any gun of any length and calibre of this early period.[180]

In the early 1720s, James entered in his notebook six iron 6-pounders, varying in length, by 6 inches, from 10 to 7-1/2 feet. Other than their lengths, he gave one further piece of information — for the gun of 8 feet, the distance from the centre of the trunnions to the base ring was 3 feet 5.14 inches.[181] This matches exactly the same length on Borgard's drawing of the 6-pounder of 8 feet. Unfortunately, not much can be made of this similarity, since most constructions adopted this proportion, 3/7 the length of the gun.

Parks has six iron 6-pounders of 8-1/2 feet and two of 9 feet at Fort Prince of Wales (Figs. 57 and 58). The former, although having no royal cypher, are probably from the reign of Queen Anne; the latter bear the cypher of King George I. Without detailed measurements it is impossible to know whether or not these guns were manufactured in accordance with Borgard's construction. The cascables of the Queen Anne guns resemble that of the 1716 drawing; those of the King George I guns are of a design usually attributed to General Armstrong.

There is an incomplete scale drawing, circa 1735 (the cascable and trunnions are missing), of a 6-pounder of 6-1/2 feet weighing 14 pounds more than 17-1/2 hundredweight, whose design seems to follow the Borgard proportions and ornamentation (Fig. 59).[182] A 6-pounder of 7 feet, weighing slightly more than 23-1/2 hundredweight, was included in the mensuration of 1743; its proportions were slightly at variance with Borgard's.[183] In 1766, Adye set down in his notebook the dimensions of a gun of 6-1/2 feet which were similar to those of the circa 1735 drawing but which were sufficiently different to prevent concluding that the two guns were the same weapons.[184]

In 1764, the Board of Ordnance established the lengths and weights of 6-pounders:[185]

Length Ft.	**Weight Cwt.**
9	24
8 1/2	23
8	22
7 1/2	20 1/2
7	19
6 1/2	18
6	16 1/2

The weight of the gun of 7 feet indicates that it clearly was not the gun of 1743 which weighed slightly more than 23-1/2 hundredweight. In 1780, Walton gave dimensions for three 6-pounders of 9, 8, and 6 feet in length whose weights correspond to those of the establishment of 1764.[186] (Again there was the aberration of the length of the second reinforce.) Elsewhere in his notebook, under the date of 1781, he listed all the 6-pounders by length and weight as set out in 1764.

In the mid-1780s or early 1790s, Blomefield introduced his construction for 6-pounders, although undoubtedly the older guns continued to be used:

Length Ft.	**Weight Cwt.**
8 1/2	23 3/4
8	22 1/2
7 1/2	21 1/4
7	20 1/4
6 1/2	18 1/2
6	17 3/4

These were for sea service and garrison.[187] It is impossible to say how extensively they were used, but by the mid-1820s most were obsolete. In 1825, Mould commented that all models from 8-1/2 to 6-1/2 feet in length were for "garrison but little used." The only gun in use, of 6 feet and 17 hundredweight, served as a chase gun in sloops of the Royal Navy. Interestingly, Mould mentioned two small 6-pounders, one of 4 feet 10 inches and 12 hundredweight and the other of 3-1/2 feet and 6 hundredweight, which he noted were no longer in use. Presumably these were land service guns made on the same pattern as the short land service 9- and 12-pounders of Blomefield design.[188]

Although most of these guns were to be found listed in various manuals over the next 30 to 40 years, except for the model of 6 feet and 17 hundredweight, it is unlikely that they were used for much besides saluting.[189] The gun of 6 feet was the only 6-pounder included in the ordnance tables in the Aide-Mémoire in 1845, and although the others were listed in the second edition of 1853, only its dimensions were set down.[190] The Committee on Ordnance, which met in the late 1850s, reported that it was the only 6-pounder actually in use.[191]

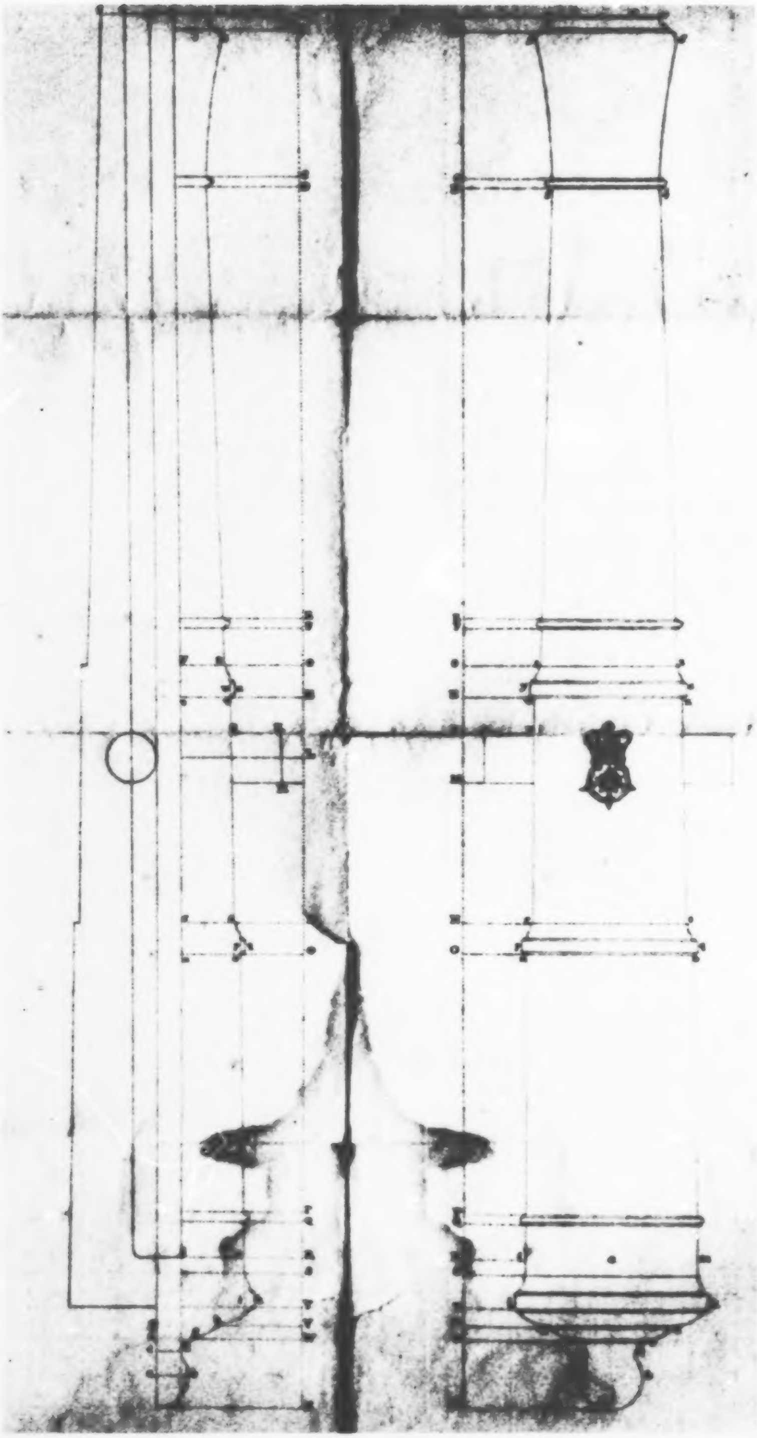


Figure 56. Iron 6-pounder, 1716, length: 8 feet. (The Royal Artillery Institution, Woolwich, U.K., Borgard, Artillery Tables, No. 30.)

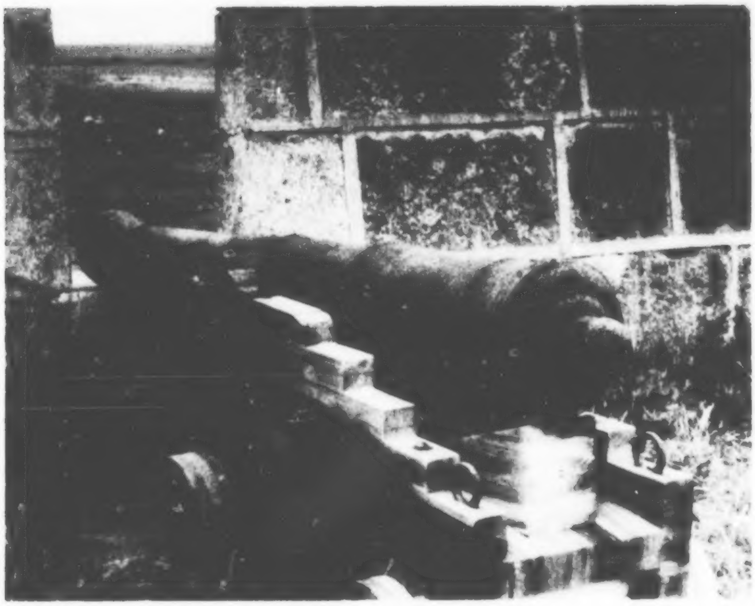


Figure 57. Iron 6-pounder, cast probably in the reign of Queen Anne (1702-14), weight: 22 hundredweight 2 quarters 7 pounds, length: 8 feet 6 inches. (Parks, Fort Prince of Wales National Historic Park.)

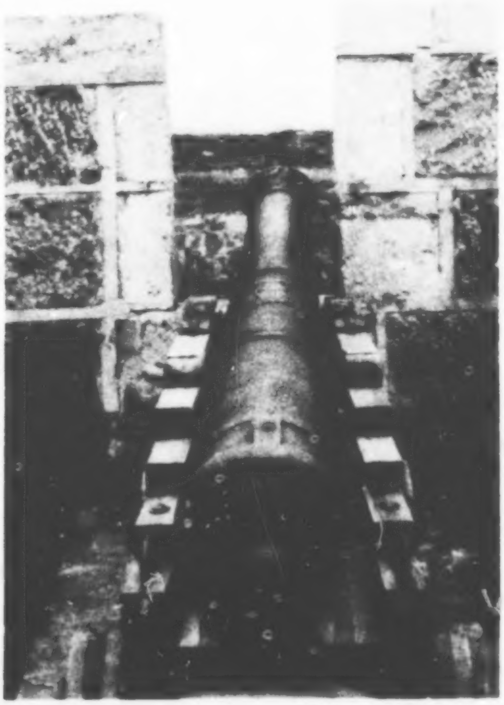


Figure 58. Iron 6-pounder, cast in the reign of King George I (1714-27), weight: 24 hundredweight, length: 9 feet. (Parks, Fort Prince of Wales National Historic Park.)

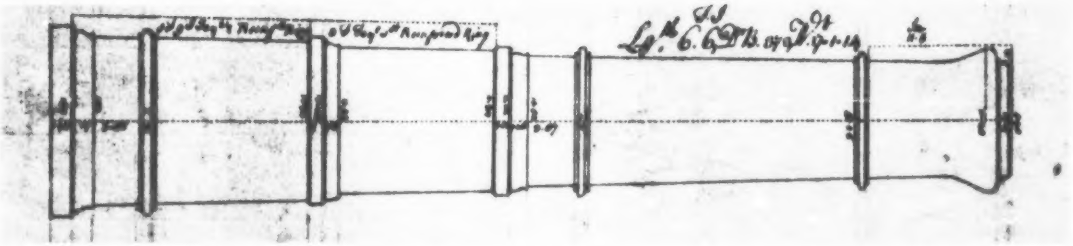


Figure 59. Iron 6-pounder, weight: 6 hundredweight 1 quarter 14 pounds, length: 6 feet 6 inches. (The Royal Artillery Institution Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

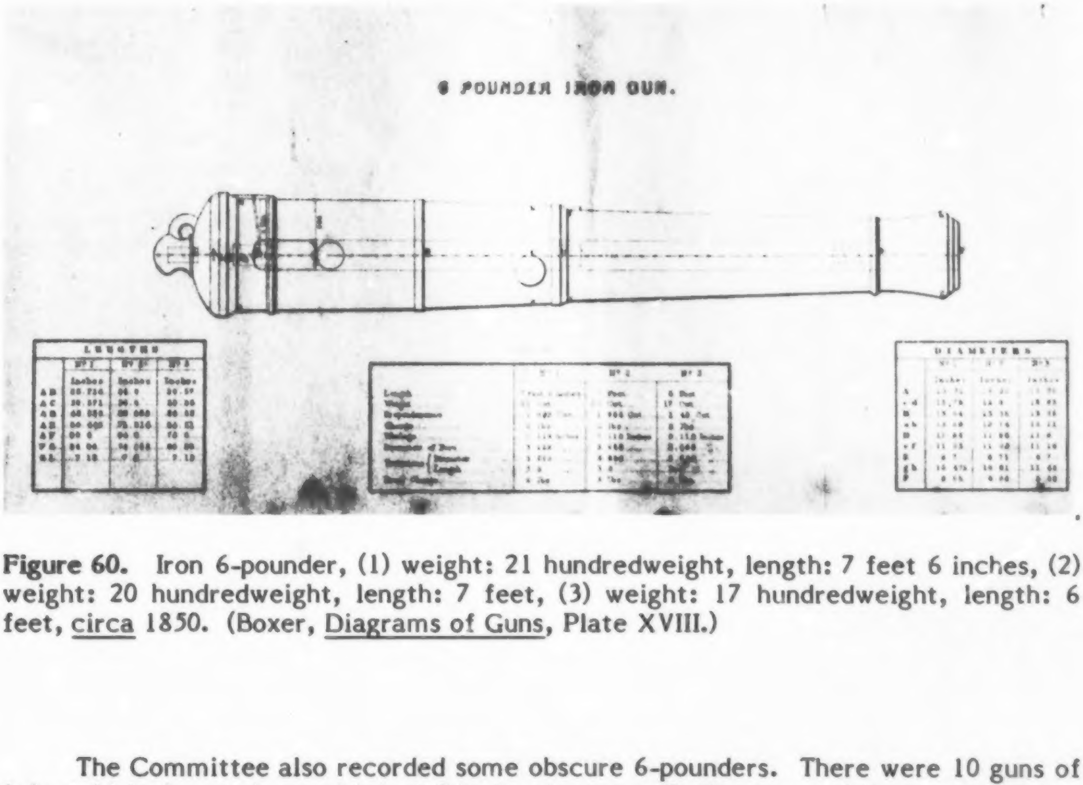


Figure 60. Iron 6-pounder, (1) weight: 21 hundredweight, length: 7 feet 6 inches, (2) weight: 20 hundredweight, length: 7 feet, (3) weight: 17 hundredweight, length: 6 feet, circa 1850. (Boxer, Diagrams of Guns, Plate XVIII.)

The Committee also recorded some obscure 6-pounders. There were 10 guns of 4 feet 11 inches and one of 4 feet 9 inches in store. Perhaps one of these was the gun of 4 feet 10 inches that Mould referred to in 1825. As well, there were two other guns of 4 feet 9 inches, designated Congreve's; these may have been similar in design to his 24-pounder. Finally the Committee noted two guns of 3 feet 6 inches, called Roebuck's and three others, also 3 feet 6 inches, presumably those referred to by Mould in 1825.[192]

The Committee recommended that all the 6-pounders be declared obsolete and disposed of.[193] Despite this recommendation, in 1865 the 6-pounder of 6 feet and 17 hundredweight was retained in service, but the remaining models were declared obsolete.[194]

4-Pounder

In the 1720s, according to James, there were five iron 4-pounders in service, varying in length, by 6 inches, from 9 to 7 feet.[195] Nothing more is known about these guns. Although a 4-pounder was not included in the mensuration of 1743, it was in use during the reign of King George II (1727-60). A gun of this calibre, bearing this monarch's cypher, 5 1/2 feet in length and weighing 11 hundredweight 2 quarters 7 pounds, has been recovered from Captain Cook's ship Endeavour.[196] Also, both Muller and Smith made reference to a 4-pounder ship's gun, from the 1750s, 6 feet in length, weighing 12 hundredweight 2 quarters 13 pounds.[197] In 1764, the Board of Ordnance included two iron 4-pounders in the official establishment - one of 6 feet and 12-1/4 hundredweight and the other of 5-1/2 feet and 11-1/4 hundredweight.[198]

Both models were referred to throughout the remainder of the eighteenth century and were listed in Adye's manual in 1801 and 1813.[199] Walton gave dimensions for both guns in 1780, but as previously noted, there was the aberration of the excessively long second reinforce.[200] As well, there is a 4-pounder, 5-1/2 feet in length, about 11-1/2 hundredweight, bearing the cypher of King George III, at the Rotunda, Woolwich (Fig. 61). Its ornamentation is very similar (perhaps identical?), to the Endeavour gun at Greenwich. It appears that its reinforces are slightly longer than those of Captain Cook's gun, thus making the length of the chase slightly shorter than the combined lengths of the two reinforces.[201]

When Blomefield prepared his system of construction in the 1780s, he included a 4-pounder of 5 feet in length.[202] It is not clear that it was actually introduced. Adye referred to the older guns and in 1825 Mould noted a 4-pounder of 6 feet and 12 hundredweight, but this was probably the older model.[203] Thereafter, the various manuals and notebooks failed to mention 4-pounders. Interestingly, a 4-pounder, bearing the cypher of King George III, 5-1/2 feet long and weighing 11 hundredweight 2 quarters 9 pounds, was captured from American filibusters at the Battle of the Windmill in 1838.[204]

3-Pounder

In his notebook in the 1720s, James set down the lengths of four iron 3-pounders, 7, 6-1/2, 6, and 5 feet, but beyond this nothing more is known for certain about these guns.[205] The 3-pounder of 6-1/2 feet, weighing 17 hundredweight 1 quarter 14 pounds, included in the mensuration of 1743 may be one of these guns.[206] A 3-pounder at Lower Fort Garry National Historic Park may have been cast during Queen Anne's reign. It is 5 feet in length and weighs 4 hundredweight 3 quarters 8 pounds. Its cascable design is similar to Borgard's, and it lacks a vent patch, characteristic of Queen Anne guns. Its ornamentation is similar to the early guns, but it does not have a chase astragal and fillets. Although the centre of the trunnions is about 3 /7 the length of the gun from the rear of the base ring, it has a very long first reinforce and a short chase. Since the broad arrow is not in evidence, it was probably cast for the Hudson's Bay Company; possibly it is contemporary with the guns at Fort Prince of Wales (Fig. 62).

The Board of Ordnance approved only one iron 3-pounder on the establishment of ordnance of 1764 - 4-1/2 feet long, weighing 7-1/4 hundredweight.[207] This length and weight of 3-pounder continued to be referred to throughout the rest of the century. Adye in 1766, and Walton in 1780, recorded its dimensions in their notebooks, but some of the diameters given by Adye are obviously wrong and the excessive length of the second reinforce given by Walton remains problematic.[208]

Figure 61. Iron 4-pounder, cast in the reign of King George III (1760-1820), weight: 11 hundredweight 1 quarter 16 pounds, length: 5 feet 6 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, III/29.)

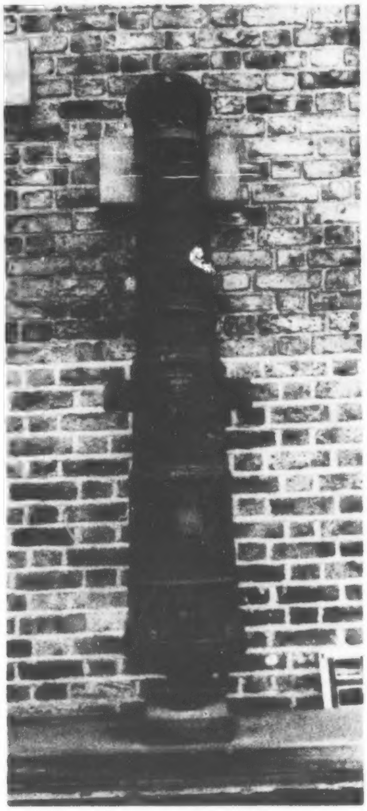
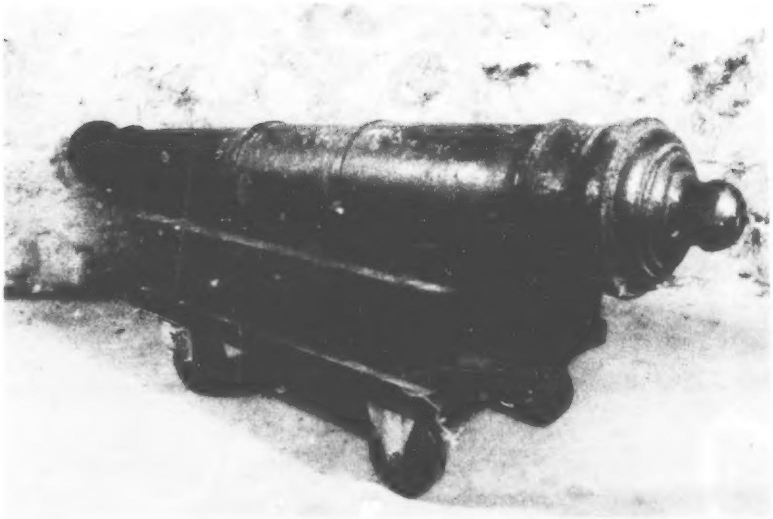


Figure 62. Iron 3-pounder, tentatively dated to the reign of Queen Anne (1702-14), weight: 4 hundredweight 3 quarters 8 pounds, length: 5 feet. (Parks, Lower Fort Garry National Historic Park.)



When Blomefield developed his method of constructing guns, he included a 3-pounder of 4-1/2 feet, but nothing is known about it, not even if it was ever cast.[209] Adye listed a 3-pounder of 4-1/2 feet and 7-1/4 hundredweight in his Pocket Gunner in 1801 and 1813, but probably he was referring to the older gun.[210] Iron 3-pounders were undoubtedly obsolete by about 1800.

There are three short 3-pounders, 3-1/2 feet long (weight unknown), preserved by Parks at Lower Fort Garry, which are very much like a land service Blomefield design in their proportions and exterior appearance. A serial number and the manufacturer's mark, S. Co., have been carved into the ends of the left and right trunnions respectively, but neither a royal cypher nor the broad arrow is evident. Probably, then, the guns were made especially for the Hudson's Bay Company (Fig. 63).

The 3-pounder made a brief and obscure reappearance during the meetings of the Committee on Ordnance in the late 1850s. It noted two sorts of 3-pounders, Roebuck's and Merchant's, but only one gun of Roebuck's design was in store.[211] Beyond this nothing is known about these guns.

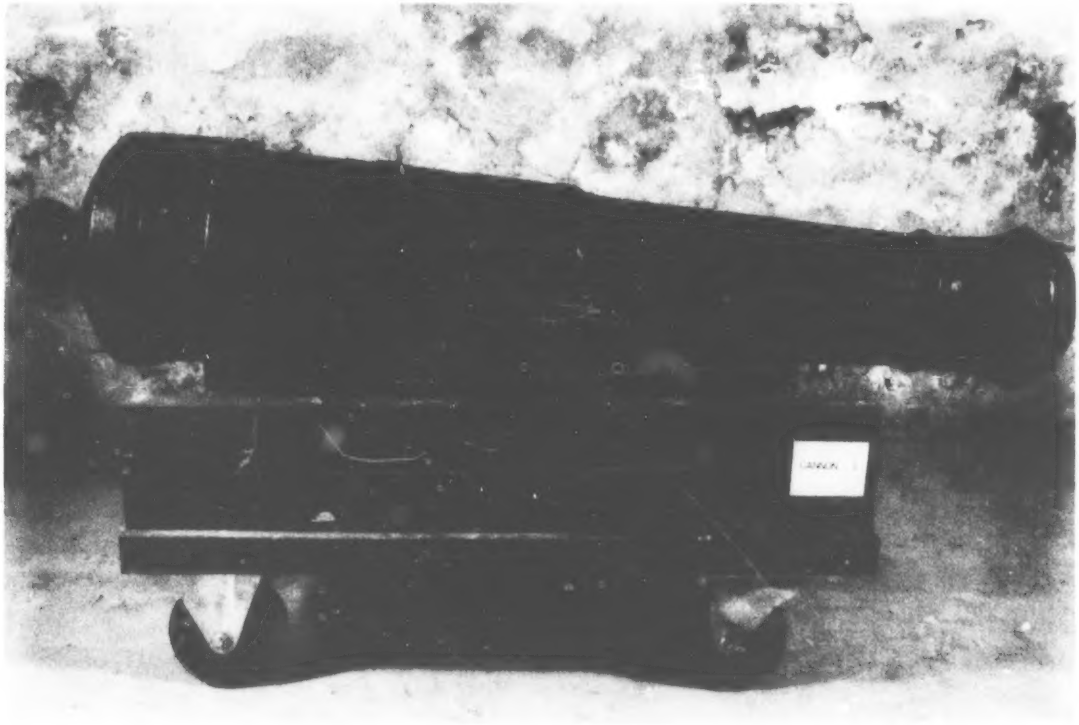


Figure 63. Iron 3-pounder, circa 1800, length: 3 feet 6 inches. (Parks, Lower Fort Garry National Historic Park.)

SHELL-GUNS

Solid shot fired from long guns and, after 1779, from carronades was the usual projectile used in naval battles. Despite shot's formidable penetrative power, sinking a ship by gunfire became increasingly difficult; ship actions had become battles of attrition, with the object being to kill or maim as many of the enemy as possible rather than to sink his ship. As a way to reduce the effects of these bloody battles of attrition the use of the explosive and incendiary capabilities of shell-fire suggested itself.[1]

Shells fired from mortars and later from howitzers, had been well-known in land warfare for centuries. The French had even adapted the mortar to naval warfare. In 1682 a French fleet of sea-going bomb ketches, specialized ships mounting mortars, had devastated first Algiers and then Genoa.[2] But mortars and howitzers, with their high trajectory of fire and their low muzzle velocities, were hardly suitable to ships of war. One problem was to project a shell from a long gun with sufficient power to lodge in a ship's side, or penetrate between decks, where it could explode with devastating effect, without its disintegrating or bursting in the barrel of the gun. A second problem was to overcome the naval prejudice against shell-fire. Sailors argued that it was both unchivalric to use shells in battle at sea and (no doubt a more important point) dangerous to store shells on shipboard.

Attempts to fire shells from guns had a long history. As early as 1674 in England, Robert Anderson had revealed in his The Genuine use and Effects of the Gunne how to shoot "Grenados" out of long guns. In 1690 a French seaman, a M. Deschiens, had learned, much to the sorrow of English and Dutch shipping that he encountered, how to project shells from guns but the "secret" died with him.[3] The English conducted experiments at Acton Common in 1760 and in Canada in 1776. During the siege of Gibraltar in 1781, they successfuly discharged 5-1/2-inch royal mortar shells from their 24-pounders into the Spanish lines.[4] In 1788, an Englishman in the Russian service, Sir Samuel Bentham, directed an inferior Russian naval force to victory over a Turkish fleet in the Sea of Azov, the latter being ripped apart by shell-fire.[5] The French, in the hope of counteracting British naval supremacy, continued experiments so successfully that in the late 1790s, 36-pounder shells were provided to their ships of war.[6]

The British retained their prejudice against shells at sea and seized upon any French disaster, such as the blowing up of the Orient during the Battle of the Nile, as evidence of the danger of shells or other combustibles on shipboard. They argued that in the confusion of battle there was too much chance of accident with shells and that in case of fire, if it spread among the shells, the whole ship could be destroyed. It was many years before they could be persuaded that no more danger existed from shells than from gunpowder stored in the ship's hold. British refusal to adopt shell-fire in naval engagements probably had more to do with a reluctance to introduce a new mode of warfare when they were supreme in the old.[7]

The French on the other hand, being the inferior naval power, had every reason to innovate. Their experiments ultimately bore fruit in the ideas of a general of artillery, Henri-Joseph Paixhans, who put them forward in two books, Nouvelle force maritime (1822) and Expériences faites par la marine française, sur une arme nouvelle (1825). In these works Paixhans combined three innovations:

(i) the development of steam driven warships,
(ii) the rationalization of calibres on board warships,
(iii) the superiority of shells over solid shot.

The successful use of the steam engine in ships of war would of course render obsolete the wind-driven navies of the world and leave the French at least equal to the British. The adoption of a single maximum calibre of ordnance, albeit of different weights, had obvious advantages in the simplification of the supply of matériel and in the provision of the greatest destructive power. But while suggesting the adoption of the 36-pounder as the standard solid shot gun, Paixhans took the argument one step further and advocated the complete armament of the French navy with guns designed to fire shells which, he argued, were superior to solid shot. Although shells, because of their lighter weight, did not range as far nor have the penetrating power of shot, nevertheless, their range was more than sufficient for the distance at which naval engagements were usually fought and their velocity was sufficient to lodge them in the sides or timbers of ships where they would explode. The destructive effect of their explosion was far greater than that of the smashing power of shot. They were fired with reduced charges from lighter guns with a shorter recoil; consequently the guns could be worked more rapidly and a greater volume of fire directed at an enemy.

Paixhans reinforced his arguments by designing his own shell-gun or canon-obusier. In essence this was a long howitzer, chambered like that weapon, with a short chase, a large bore (22 cm. or about 8.7 inches), no muzzle swell, and all the extraneous ornamentation (rings, astragals, fillets) removed. Tests were held at Brest in 1821 and 1824 with such impressive results that the commission observing recommended the adoption in small numbers in ships of the line of the newly designed weapon. Noting perhaps its low muzzle velocity (armour could repel a shell) and its relatively short range, the French navy was less impressed. Although it adopted Paixhans views on the standardization of calibre in 1829 (the 30-pounder was chosen as the unit), more trials of the shell-gun were held and its design modified. Finally in 1837 the principle of shell fire was accepted and the Paixhans gun, alongside the 30-pounder, was accepted as part-armament of the French navy.[8]

The British, although perhaps not wishing to lead the way but well aware that they must keep abreast of advances, also began experiments with a shell-gun. As early as 1820 Colonel William Millar of the Royal Artillery had designed and was experimenting with what he called a 68-pounder, designed to fire both shot and shell, which was the prototype of the 8-inch shell gun. In 1824 a 10-inch gun was proposed for the navy but was found to be too heavy and was replaced by the 8-inch calibre. Various models of 8-, 10-, and even 12-inch guns were tested throughout the 1830s. Finally by 1839, in reaction to the French reforms, the British had adopted various lengths of 32-pounders as the standard shot gun and two lengths of the 8-inch shell gun (9 feet of 65 hundredweight and 8 feet of 52 hundredweight) for the armament of the Royal Navy.[9]

8-Inch Shell-Gun

This first reference to the 8-inch shell-gun occurred in 1820. In September of that year, "Colonel Millars sic 68 P^{r} Gun of 10 Calibres & Cw^{t} 50.0.0" was tested, firing both shot and shell. Although it was called a 68-pounder and so designated in manuals for a number of years, this was obviously the prototype 8-inch shell-gun (Figs. 64 and 65).[10] It was first introduced into the naval service in 1825 when the newly designed 10-inch gun was deemed too heavy for ordinary ships (for the 10-inch gun, see below).[11] Two 8-inch guns were assigned to the lower deck of 2nd rates to replace 68-pounder carronades.[12] This model was quickly found to be too short and

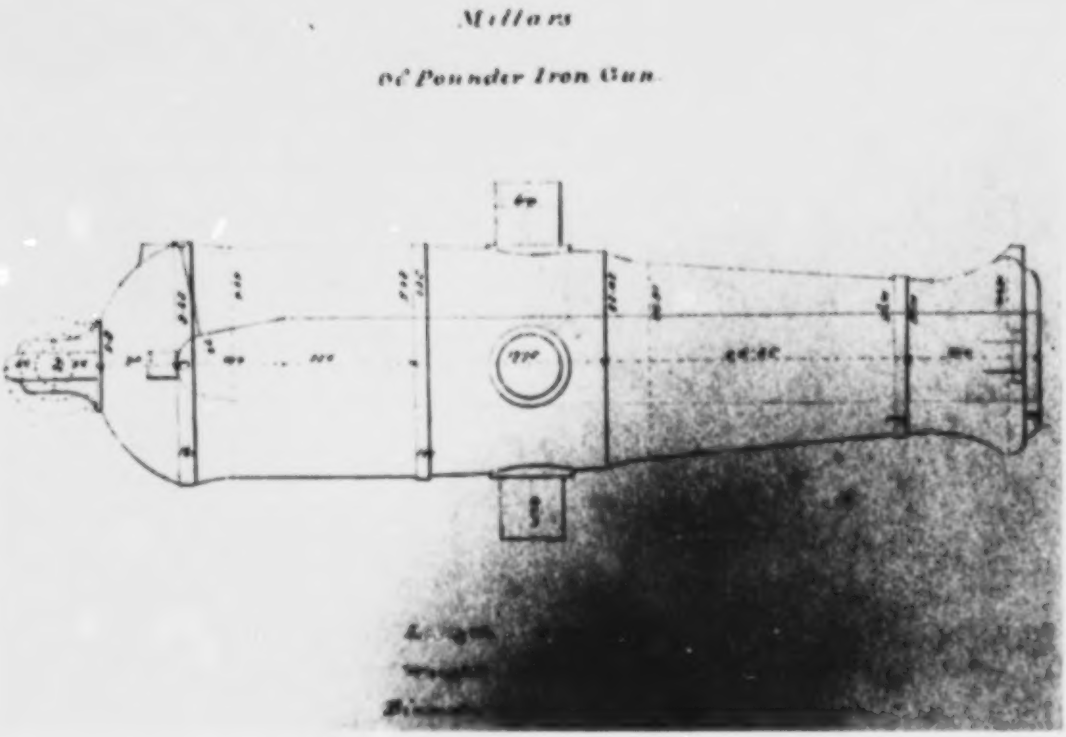

Millars
68 Pounder Iron Gun

Figure 64. Iron 68-pounder, Millar design, weight: 50 hundredweight, length: 6 feet 8.5 inches. The prototype shell-gun, circa 1825. (Royal Military College, Mould, p. 103.)

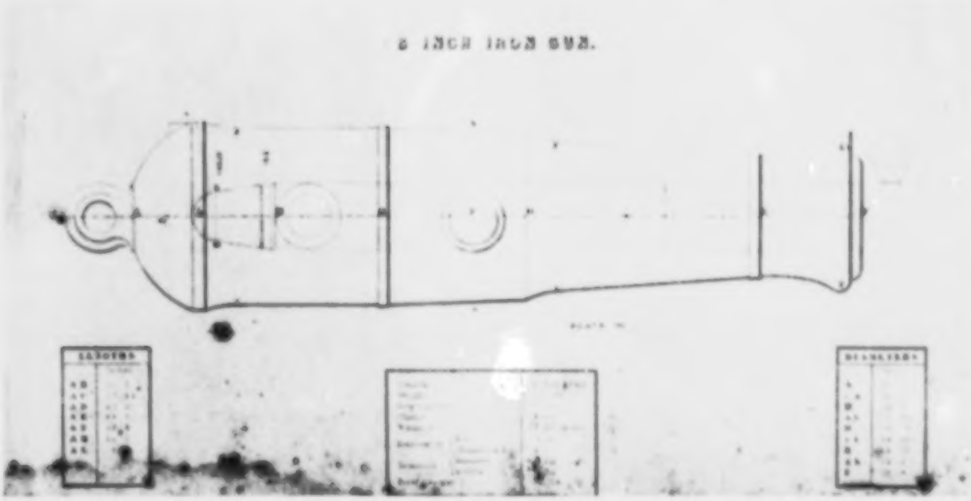

8 INCH IRON GUN.

Figure 65. Iron 8-inch shell-gun, weight: 50 hundredweight, length: 6 feet 8.5 inches, circa 1850. (Boxer, Diagrams of Guns, Plate IV.)

light and was replaced by longer and heavier 8-inch guns, although it was still retained on the list of active ordnance.[13] In fortresses or batteries it was probably seen as a substitute for the 8-inch howitzer. In 1845 one artillery officer remarked.:

> The 8-inch gun, of 6 feet 8-inches [sic], 50 cwt., appears to be much preferable for firing through embrasures, to the 8-inch howitzer (but 4 feet long); both may be used for firing en barbette from traversing platforms.[14]

It was for a short time considered as a suitable weapon to be included in the armament of coast batteries and "for flanks, interior defences, and for commanding landing places."[15] In 1857, there being only 15 of these guns remaining, all in store in Great Britain, the Committee on Ordnance recommended that it be declared obsolete and, finally, in 1866 it was so declared.[16]

Douglas, in his Treatise on Naval Gunnery, maintains that in 1838 the 50 hundredweight gun was replaced by the 8-inch gun of 9 feet and 65 hundredweight.[17] He does not mention another model, of 8 feet 10 inches and 60 hundredweight that was first introduced in 1831.[18] It first appeared in a manual in 1844 where it was designated for garrison use. This designation, if correct, may account for Howard's neglect.[19] But by 1848 it was being described as a sea service gun and by 1857 there were 120 of these weapons on board ship, none being mounted on land, either in Great Britain or abroad.[20] In 1857 the Committee on Ordnance recommended that it be declared obsolete but as late as 1881 it was still retained on active service.[21]

As previously noted, Douglas wrote that the 8-inch gun of 9 feet and 65 cwt. was introduced for steamers in 1838. Other writers have said that it was first brought forward in 1834.[22] Possibly Douglas was suggesting that it was not officially accepted until 1838 and had been under trial for four years. This model was the most popular of the 8-inch guns; 4157 of it were ordered from contractors between 1834 and 1862 for both land and sea service.[23] In 1881 it was still in service. Many were converted to 64-pounders R.M.L. of 71 hundredweight.[24]

A very obscure model of 8 feet 6 inches and 60 hundredweight was first noted in a manual of 1839.[25] It was reportedly designed for sea service.[26] Its career seems to have been very short, possibly only from 1840 to 1846 when 110 of these guns were manufactured.[27] By 1857 only six were reported, all in store in Great Britain, and the Committee on Ordnance recommended that it be declared obsolete.[28] Presumably this recommendation was implemented for with the exception of the note on production this model was not mentioned again.

A fifth 8-inch gun, of 8 feet and 52 hundredweight, was introduced in 1840, but it was not noted in any of the manuals until 1847.[29] Although originally designed for naval service, it received its most extensive use in the siege train sent to the Crimea in 1854, where, mounted on a modified 24-pounder carriage, it served as a howitzer.[30] In 1858 the Committee on Ordnance recommended its retention in the service and in 1859 it was decided that the piece was the most suitable for the armament of caponnières and flanks of works (Fig. 66).[31]

According to Sir Howard Douglas, this model of the 8-inch gun was an inefficient weapon:

> It is commonly said that 8-inch shell-guns of 52 cwt. — an inferior and inefficient class of shell-guns, of which vast numbers have been provided, but which are rapidly and justly falling into disfavour and disuse in the naval service ... — form a large portion of the present siege-train service; not it is hoped, to interfere with the usual proportion of the good old 24-pounder — a capital siege-gun — but to be used as howitzers; for they are incapable of serving with efficiency as battering ordnance (excepting against earthen works ...), or for

> richochet [sic], with shot; and they are very inconveniently heavy howitzers for siege service.[32]

Despite Douglas' strictures, the 52 hundredweight gun was retained in service and sometime in the 1860s it was slightly modified by the addition of 2 hundredweight, probably by adding additional metal to the breech and perhaps removing some from the chase, a modification which had been carried out upon the 10-inch gun (see below).[33] The gun was still in use in 1881 although there were "but few of the 54-cwt. pattern mounted in L.S. batteries."[34]

The Committee on Ordnance noted one other 8-inch gun, of 5 feet 8 inches and 36 hundredweight. On 31 March 1857, 11 of these, which had been supplied sometime before 1854, were in store in Great Britain. The Committee recommended that it be declared obsolete.[35] This is all that can be said of this piece, since nowhere else is it mentioned. It remains a most obscure weapon.

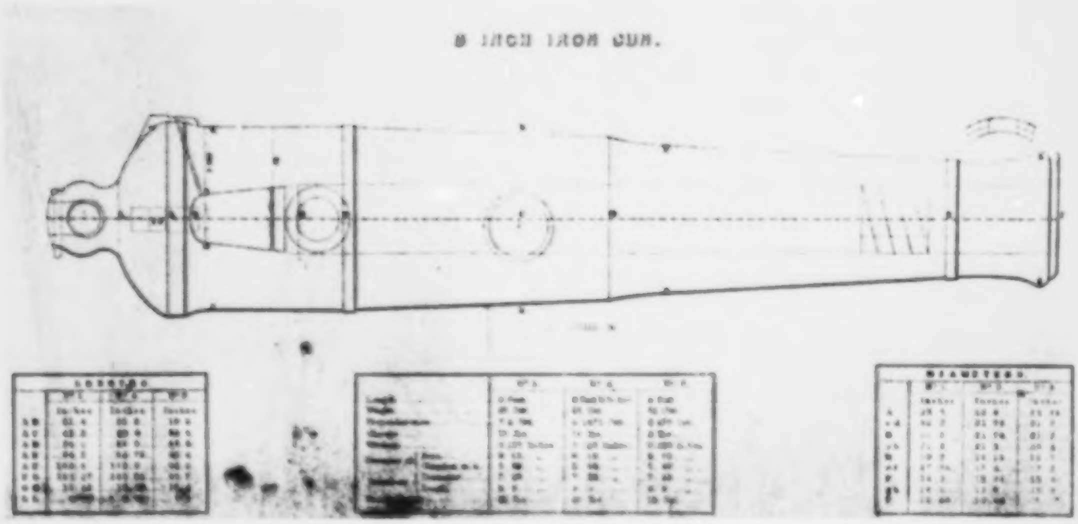


Figure 66. Iron 8-inch shell-gun, (1) weight: 65 hundredweight, length: 9 feet, (2) weight: 60 hundredweight, length: 8 feet 10 inches, (3) weight: 52 hundredweight, length: 8 feet, circa 1850. (Boxer, Diagrams of Guns, Plate III.)

10-Inch Shell-Gun

A potentially more powerful but ultimately less successful weapon than the 8-inch was the 10-inch shell-gun. This weapon, of 9 feet 4 inches and 84 hundredweight, was first introduced into the naval service in 1824, but, because it was found to be too heavy for an ordinary ship, quickly gave way to the 8-inch gun.[36] Despite its initial failure it never completely fell from favour. About 50 were manufactured between 1831 and 1840.[37] It was part of the extensive gunnery trials at Deal in 1839[38] and in 1845 one artillery officer regarded it as a formidable weapon for coastal batteries. The 10-inch shell-guns, he wrote,

> Are most eligible pieces for sea defences.

> The diameter and weight of the shell, and its explosive effect when filled with powder, must have most destructive effect upon any vessel.
>
> The 10-inch gun of 9 feet 4 inches, 84 cwt. may be fired with advantage through an embrasure from a dwarf traversing platform, or from a traversing platform, en barbette over a parapet. By means of a bearer the shell, though heavy, may be readily raised to the height required to load.[39]

In 1846 the Millar model was modified by Colonel W.B. Dundas, Inspector of Artillery. The weight was increased by 2 hundredweight to 86 hundredweight by adding 4 hundredweight of metal around the breech and charging cylinder and removing about 2 hundredweight from the chase.[40] This new model superseded the original gun but the latter still continued to be used but exclusively on ships. The heavier weapon served both on land and at sea.[41] Even with the additional weight it was still suspect. Although the Committee on Ordnance recommended that it be retained in service, it felt constrained to direct "that its enduring powers should be ascertained by experiment ..."[42] Artillerists argued that it was a formidable weapon at short range, but that it was inaccurate at long range. The 68-pounder, 32-pounder, and 8-inch gun were felt to be superior (Fig. 67).[43]

The lighter 84 hundredweight gun slowly passed from the scene. In 1866 it was abolished and by 1873 only the 86 hundredweight gun was in use.[44] By 1881 it was still listed in service, but it did cause some problems at times:

> The muzzle of this gun being too large for the ports of some ships, one of the muzzle mouldings was sometimes turned off in order to obtain a larger angle of training. Guns so treated are called L.M. (low muzzle), in contradistinction to the H.M. (high muzzle).[45]

There were two other models of 10-inch guns — one of 7 feet 6 inches and 57 hundredweight and one of 8 feet 4 inches and 63 hundredweight. Seven of these (three of the former, four of the latter) were constructed in 1829 but only for

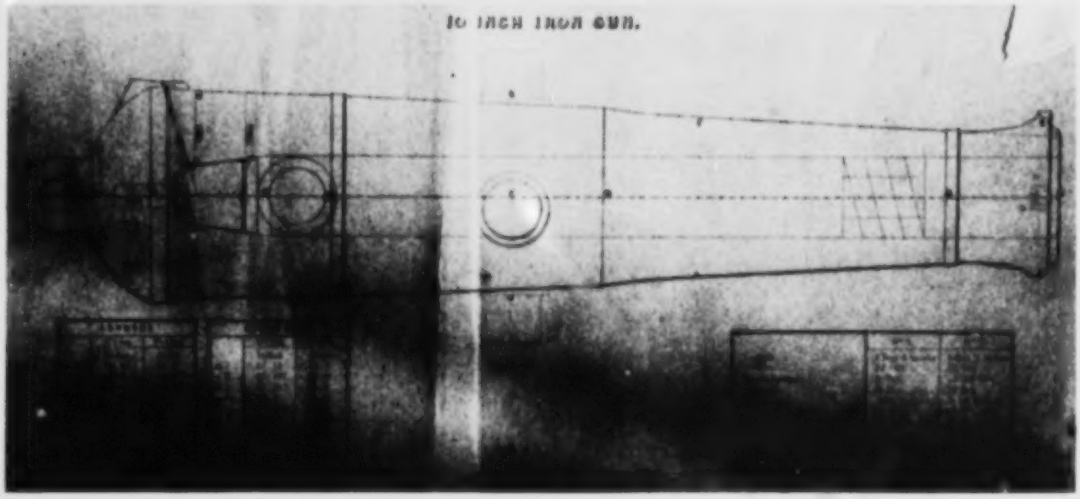


Figure 67. Iron 10-inch shell-gun, (1) weight: 87 hundredweight, length: 9 feet 4 inches, (2) weight: 84 hundredweight, length: 9 feet 4 inches, circa 1850. (Boxer, Diagrams of Guns, Plate I)

experiment and were never accepted into service.[46] The Committee on Ordnance noted their existence in 1857 (three of each model) and the next year recommended that they be declared obsolete.[47] In 1866 they were finally abolished.[48]

12-Inch Shell-Gun

A 12-inch shell-gun of 8 feet 4 inches and 90 hundredweight was proposed and cast in 1828, but, according to Miller, only one specimen was ever manufactured.[49] There is, however, in Straith's Atlas which accompanied his artillery manual of 1841 a drawing of a 12-inch shell-gun said to be of 9 feet 2 inches and 5 tons (about 89-1/4 hundredweight).[50] An earlier notebook also noted a 12-inch shell-gun of 9 feet 2 inches but weighing 100 hundredweight.[51] All other manuals, if they recorded a 12-inch gun at all, referred to the model of 8 feet 4 inches. The question of whether there were one or two specimens, however, is purely academic, because the 12-inch gun never came into use.

CARRONADES

The carronade was a short, light piece of cast-iron ordnance with a large bore relative to its weight. The bore terminated in a cylindrical chamber, its diameter equal to the preceding calibre. Although it fired the standard shot, the windage around the ball was less than normal because the bore diameter was slightly smaller than in the corresponding gun. Since its light weight necessitated the use of a reduced powder charge, the carronade was a relatively short-range weapon.

Its profile was distinctive. It lacked a muzzle swell and the mouth of bore was enlarged or "scooped" to facilitate loading. An unusual dispart sight was usually cast on the reinforce ring, although on early models it may have been mounted on the muzzle. Two rings projected behind the uniquely designed cascable, a vertical one for the breeching rope, and the other, horizontal, threaded for the elevating screw. Although some carronades were cast with trunnions, most had a loop or "joint" underneath through which a bolt passed to attach them to their carriages. The carriage was constructed in two parts — a lower one attached to a pivot in the ship's side and an upper one, held in place by a bolt protruding down through a slot in the lower, along which the upper part recoiled until checked by the breeching rope.

The appearance of the carronade in 1778 was the result of the practical application of the ideas of artillery theorists like Benjamin Robins and John Muller, ideas which had been discussed for 30 years or more. Robins, mathematician and military engineer, author of the influential New Principles of Gunnery, published in 1747 a pamphlet, A Proposal for increasing the strength of the British Navy, by changing all guns from 18-pounders downwards into others of equal weight but of a greater bore. Noting that lighter pieces became proportionally heavier relative to the weight of the shot, he argued for a more efficient allocation of metal, thereby decreasing the weight of the smaller calibred guns. In effect, this would allow the smaller ships of the navy to carry larger calibre guns without any increase in the dead weight of the metal on board. At the same time to limit the stress on the guns, Robins called for a reduction in the powder charge to one-third the weight of the ball. Admitting that his proposal to increase the calibre of a warship's guns would be at the expense of ranging power, he pointed out that most naval duels were fought at close quarters and that the destructive effect of a cannon ball increased disproportionately to its increase in size.[1]

John Muller, professor of artillery and fortifications at the Royal Military Academy, Woolwich, also called into question in his A Treatise of Artillery the excessive weight of guns. While Robins had been concerned with sea ordnance, Muller applied his reasoning to all types of guns, developing a system of construction in which his proposed pieces would be both lighter and shorter.[2] Also, Muller questioned the excessive windage of British guns and proposed that it be reduced to 1/24 the diameter of the shot.[3]

The carronade was developed by the Carron Company, ironfounders of Falkirk, Scotland. This firm, founded in 1759, was determined to become a major foundry of cast-iron ordnance. Its first attempts in 1761-2 to supply the Board of Ordnance were frustrated by the proofing failures of too large a percentage of its guns. In 1764 the company resumed its attempt to become the major supplier to the Board, and for the next nine years achieved a modest success. But again, in 1773, a high proportion of its guns failed and the Board declined to place further orders.

Despite this setback, or perhaps because of it, Carron endeavoured to improve its methods of producing ordnance. In 1775 the company began to cast barrels solid rather than on a core and adopted John Wilkinson's method of horizontal boring (see above). From 1776 to 1778 the foundry produced successfully a number of light-weight, small-calibre guns, the plans of which are lost, but which apparently approximated the carronade. There is in the Tower of London two short swivel guns, 4 pounders, with trunnions, cast by Carron in 1778, that may be an example of these forerunners.[4] Out of this ferment of innovation Carron developed the carronade. It was first tested in the autumn of 1778.[5]

While it is beyond dispute that the carronade was first manufactured by the Carron Company, it is not clear which individual was responsible for the design of the weapon. There have been three claimants of the honour — General Robert Melville, Charles Gascoigne, and Patrick Miller.[6] Naval historians have credited the invention to Melville, an intelligent, well-read, infantry officer who was interested in problems of gunnery. An appreciation of Benjamin Robins' arguments led Melville, according to the naval historian, Robertson,

> to propose, in 1774, a short eight-inch gun weighing only thirty-one hundredweight yet firing a nicely fitting sixty-eight pound ball with a charge of only five and a half pounds of powder. This piece he induced the Carron company to cast, appropriately naming it a Smasher. Of all the carronades the Smasher was the prototype...the carronade was a reproduction, to a convenient scale, of the Smasher.[7]

Robertson cites as conclusive evidence that Melville was the inventor the inscription on a model that the Carron Company presented to the soldier:

> Gift of the Carron Company to Lieut.-General Melville, inventor of the Smashers and lesser carronades for solid, ship, shell, and carcass shot, etc. First used against the French in 1779.[8]

R.H. Campbell, in his history of the Carron Company, is less dogmatic in his attribution of credit.[9] He points out that the strongest evidence in Melville's favour is his own letter written on 31 July 1797, some 20 years later, and a subsequent brief reference in another letter that he dictated on 1 July 1806. According to his own testimony, he conceived the idea of the carronade in 1753 when, as a captain of the 25th Regiment, he was stationed at Cork. He told members of the Carron Company of his speculations, who then constructed and tested successfully an 8-inch model. Unfortunately the Board of Ordnance was not interested, but the company began to produce smaller carronades for the use of privateers and on its own ships. In commenting on Melville's assertions Campbell points out that there is no evidence surviving of the testing of a heavy proto-carronade previous to the development of the lighter sorts. He suggests that Melville, in his old age, may have confused these trials with those of a 100-pounder in 1781, records of which are extant.[10] But it is clear, argues Campbell, from extensive correspondence in the company records, that "if Melville did not invent the carronade, he was constantly being consulted on its development," and that his basic contribution to the development of the carronade was to suggest "the possibility of lighter but equally effective cannon, if they had chambers like howitzers."[11]

A suggestion coming from Melville, such as casting the bore of a cannon with a chamber, could be picked up and implemented by a founder like Charles Gascoigne, manager of the Carron works and another claimant to the title of inventor of the carronade. The evidence for his claim is less straightforward then Melville's, comprising the attribution of the invention to him by the Scots Magazine in 1779, the fact that the original name of the carronade was "gasconade," references in certain letters to "our C.G. Esqrs. invention," and his unsuccessful attempt to patent the weapon in his name. Campbell points out that Gascoigne was often vague in his descriptions of the uniqueness of the weapon and suggests that he was developing a good idea that he had come across without fully understanding its distinction.[12]

Patrick Miller, banker and merchant of Edinburgh, strongly asserted his own claim to be the inventor but, like Melville, years after the event. He contended that he conceived the idea to use light guns with reduced charges for short range engagements at sea, contracted with the Carron Company to cast and test 12-pounders, and, in the autumn of 1778, fitted out a private ship, Spitfire, with them. Campbell indicates certain weaknesses in Miller's claim, but admits that Miller was indeed involved in the Spitfire venture, that he was an interested amateur in engineering and mechanical ventures, and was an active and enthusiastic promoter of the sale of the carronade after its invention. Campbell is inclined to see Miller more as promoter rather than as inventor.[13]

Campbell's final conclusion is judicious:

> From this welter of conflicting evidence it is difficult to determine who invented the carronade. Probably all three were involved...

He argues strongly that Melville and Gascoigne, through their interaction and expertise, made the most significant contribution while Miller, in the role of wealthy amateur, encouraged and later promoted their work.

> Yet is is really impossible to state the carronade's inventor dogmatically. It first appeared at Carron and most truthfully of all it may be said that all who had any connection with the Company – which includes Melville, Gascoigne, and Miller - were all involved in this major operation.[14]

The carronade was first tested in action in the autumn of 1778 when Gascoigne engaged his kinsman, Captain William Elphinstone, to carry Carron goods to London in exchange for arming the latter's ships. The results of these trials of what was initially called the gasconade are unknown, but the news of this new weapon was sufficient to prompt many enquiries from merchants. Then the Spitfire of Liverpool, armed with 16 carronades, engaged a French frigate of nearly four times her burthern and, while eventually striking her colours, damaged her enemy severely. In December 1778 the company gave Gascoigne permission to produce the new weapon, now officially dubbed carronade, for general sale; shortly orders were flooding in. Subsequent accounts of successful actions against French or American ships only enhanced the cararonade's reputation in unofficial circles.

The government responded more slowly, but in May 1779 sufficient pressure was brought to bear that the King ordered trials of the carronade at Woolwich. By July the Admiralty had accepted the new weapon and shortly was demanding large quantities. By January 1781, according to the naval historian William James, 429 ships of the Royal Navy mounted carronades.[15]

The first major action in which carronades contributed to victory occurred on 12 April 1782 when the British under Rodney defeated the French under de Grasse at the Battle of the Saints in the West Indies. That same year, in the most dramatic demonstration of the power of the carronade in favourable circumstances, the British Rainbow, armed entirely with carronades, decisively defeated the French frigate, Hébé, in a very short exchange. By the end of the War of the American Revolution the carronade was well established both in official and in unofficial circles.[16]

The radical design of the carronade was responsible for its dramatic success at sea. Since it was very light and short it could be eaily manoeuvred and worked by fewer men than the corresponding calibre of long gun. As well, a lighter piece fired a heavier shot. Even the largest of the carronades, the 68-pounder of 36 hundredweight, was only slightly heavier than a 12-pounder long gun. This was especially advantageous for a small ship, such as a merchantman or privateer, which, by substituting carronades for long guns, became capable of throwing four or five times the weight of projectile without increasing the dead weight of her weapons. As long as she fought at close range, a carronade-armed vessel could be a dangerous adversary against a ship that, under normal circumstances she would not have dared to approach.

The low velocity of the shot, the reduced windage, and the large ball were all advantageous characteristics of the carronade. Gunners knew that a shot which had just sufficient velocity to pierce a ship's side caused the most damage. A high speed ball often passed through both sides without causing more damage than two small holes. A larger ball caused damage out of proportion to the increase in size, especially by the splintering effect which scattered slivers of wood in all directions, killing or maiming the men in the nearby gun crews. The small windage meant that the utmost effect was achieved by the reduced powder charge, since less of the force of the explosion was lost escaping around the ball.[17]

The disadvantages of the carronade derived from precisely those characteristics that gave it its advantages. Its critics charged that its shortness prevented it from extending sufficiently beyond the ports of a ship, thus creating a danger of setting fire to the rigging or indeed to the side of the vessel. Between decks, the detractors added, there would be an increase in the amount of smoke collecting, thus blinding and choking the gunners. The speed with which the carronade could be worked and fired could result, it was feared, in overheating and bursting. The recoil, which was said to be especially violent due to the light weight of the carronade and the peculiar method of its mounting by a loop underneath the barrel, could so stretch the breeching rope that, when the upper part of the carriage recoiled the metal bolt would strike the rear of the guiding slot in the lower carriage, breaking it, and thus disabling the weapon.[18]

These criticisms could be answered but the major weakness, the carronade's short range, was a more serious problem. In battle at short range the carronade was formidable. A spectacular example was the case of Glatton, a former East Indiaman in Admiralty service, armed exclusively with carronades. Attacked by six French frigates, a brig-corvette, and a cutter off the coast of Flanders in 1795, she drove them off, all badly damaged. But if the enemy refused to fight at close quarters, the carronade was useless. Commodore James Yeo discovered this on Lake Ontario in 1813, complaining that he could not bring the American ships to close action, "not a carronade being fired." The American frigate Essex, armed almost exclusively with carronades, was pounded into submission by two British warships who stood off at long-gun range and refused to close. By the end of the Napoleonic wars the reputation of the carronade was considerably diminished.[19]

Thereafter the carronade began to be supplanted by lighter guns. In 1825 a student at the Royal Military Academy noted that a variety of 68-pounder was no longer in service and that the other was to be retained in use only "'till Gen^{l}. Millars 68 P^{r}. Guns are ready." According to his notes, only the 32-pounder carronade was in general use in the Royal Navy; the other calibres were in service in the lesser rates, in boats or cutters, or in fortresses where they were used for flanking fire.[20] A French commission visiting England a decade later noted that carronades, while still in use, were being replaced by light guns of a new construction.[21] In 1846, one military writer, Hector Straith, argued strongly for the use of 68-pounder carronades to scour narrow ditches or other fixed positions in fortresses because they fired a large charge of case or grapeshot and could be worked very quickly.[22] But even in this restricted use, he noted, they were being replaced by reamed-up guns:

> Carronades are however so inferior to guns in most respects and they project so short a distance out of the embrasures, that they are becoming increasingly objected to, and a preference is now given to reamed up guns of heavy calibre...[23]

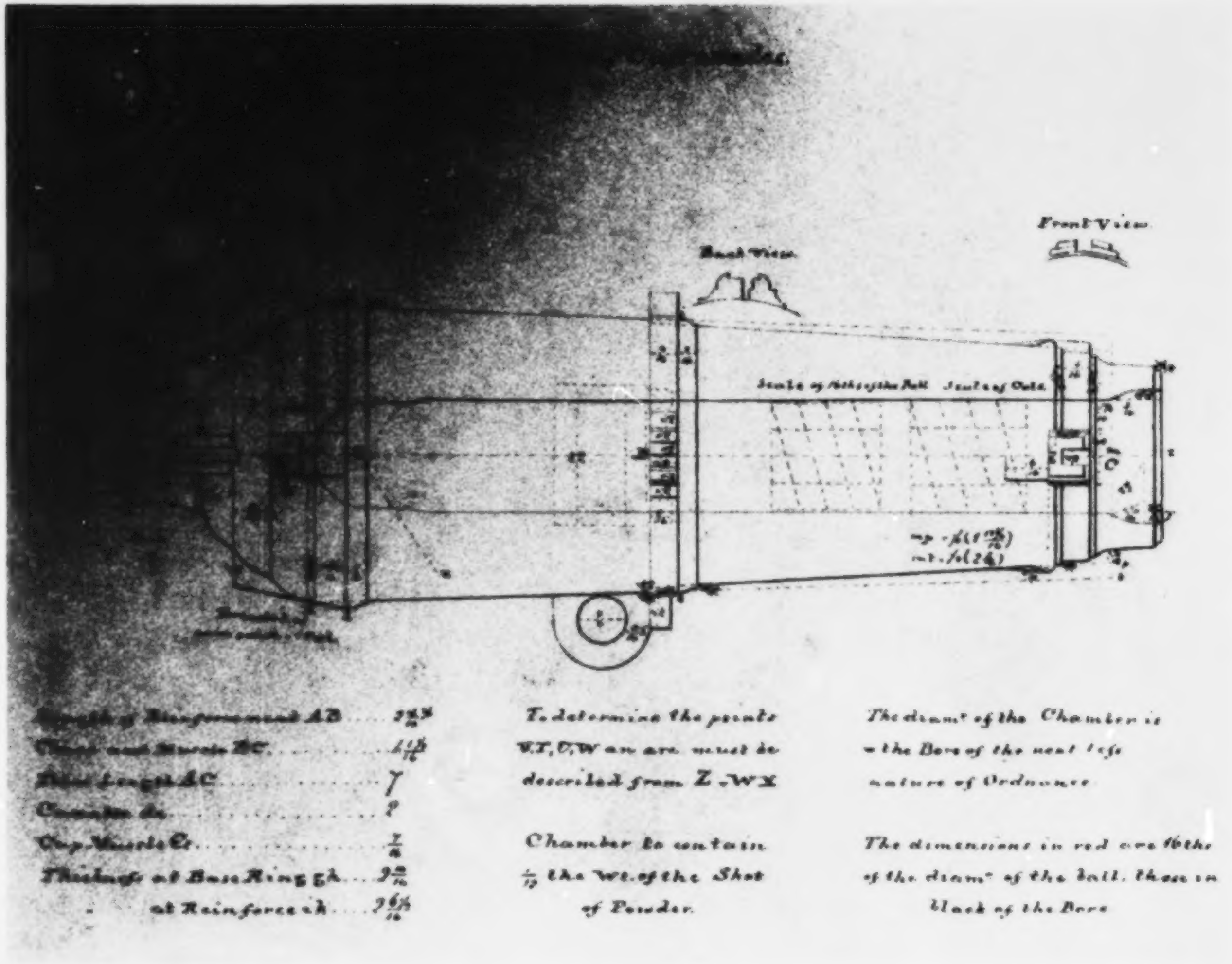

Front View
Back View
Scale of Diameter of the Ball
To determine the points
V.T, U.W an arc must be
described from Z .WX
Chamber to contain
1/17 the Wt. of the Shot
of Powder.
The diamr of the Chamber is
= the Bore of the next less
nature of Ordnance
The dimensions in red are 16ths
of the diamr of the ball, those in
black of the Bore
Thickness at Base Ring gh
at Reinforce ik
7

Figure 68. General Construction of Carronades, circa 1825. (Royal Military College, Mould, p. 102.)

In 1864 they were used only for the flank defence of permanent works.[24] A year later the existing 68-, 42-, 32-, and 24-pounders were retained in the service "either permanently or for a time" and in 1866 the lesser calibres were declared obsolete.[25]

The career of the carronade may be summed up in the words of Sir Howard Douglas, an expert on naval gunnery:

> The defects of carronades, and the danger of employing that imperfect ordnance, are now generally felt and admitted; that ordnance, however, rendered important service in its time, for it taught us practically the great value of a reduced windage, the advantage of quick firing, and the powerful effects produced at close quarters by shot of considerable diameter striking a ship's side with moderate velocity.[26]

Chambered like a howitzer but firing solid shot, it was replaced in naval warfare by the shell gun, which in essence was merely a long howitzer.

Carronades were cast in all calibres from the 3- to the 68-pounder, except the 56-pounder. There is some controversy whether the heavy 68-pounder was developed before the lighter calibres. The older view, previously noted, holds that the Carron Company began to produce the lighter models following the failure of the Admiralty to express any interest in the "Smasher" that Melville allegedly had cast in 1774.[27] R.H. Campbell, in his more recent study of the Carron Company, argues that the lighter carronades were developed first, pointing out that there are no records of the tests of 68-pounders until 1780.[28] Whatever the truth, by 1780 carronades of a calibre from 12- to 68-pounder had been successfully tested and were in service.

The history of the lighter pieces, the 3-, 6-, and 9-pounders, is more obscure. The first reference to these, and the only reference to the 3-pounder, occurred in a table of powder charges dated 1797.[29] In it the term "Merchant's" was appended beside them, suggesting perhaps a different design. There are no subsequent reports of a 3-pounder, but in 1825 the 6-pounder was said to be in use on King's and revenue cutters.[30] It continued to be included in lists of ordnance until it was declared obsolete in 1866.[31] The 9-pounder was first noted in the Queen's service in 1847, but by 1859 it was slated to be declared obsolete.[32] Presumably it was so declared, but it is not included in the 1866 list of obsolete pieces. It seems to have been a rather obscure weapon.

Although no examples or drawings of the 6- or 9-pounder exist, the specifications that have been found indicate that in length and weight they were proportionately longer and heavier than the other carronades. The 6-pounder, 2 feet 9 inches, and the 9-pounder, 4 feet, were respectively slightly more than 9 and 11-1/2 calibres long as opposed to the usual length for long carronades of from 7 to 8 calibres. The ratio of weight of shot to weight of carronades was about 1 to 88-1/2 for the 6-pounder of 4-3/4 hundredweight and about 1 to 99-1/2 for the 9-pounder of 8 hundredweight. The usual ratio varied from 1 to 50 to 1 to 60.[33]

In his study of British smooth-bore artillery, Hughes lists neither the 3- nor 9-pounder and of the 6-pounder he notes: "Probably not in service after 1810. Not mentioned in tables of armaments after 1813."[34] This must be a typographical error, for the author himself reproduces tables of dimensions which include the 6-pounder.[35] He must mean not in service before 1810 and not mentioned before 1813. It was certainly mentioned from the mid-1820s onward.

The heavier calibres were in service from 1779 or 1780 until the mid-1860s (and perhaps later in remote posts), although they were obsolescent by 1840 or before. The 12- and 18-pounders were tested at Woolwich in 1779 and all calibres were put on trial there the following year.[36] Some of these models do not appear thereafter — e.g, a 12-pounder of 1 foot 10 inches and more than 4-1/2 hundredweight and an 18-pounder of 3 feet 1/2 inch.[37] It is hardly surprising that different lengths and weights were tried until a satisfactory size was selected.

Two sizes of carronades were developed — a shorter version about 5.9 calibres long, with a ratio of shot weight to total weight of about 1 to 52, and a longer model about 7.7 calibres long, with a ratio of shot weight to total weight of about 1 to 59. From the beginning both varieties of the 18-, 24-, and 68-pounders co-existed, the shorter type becoming obsolete probably in the 1820s and certainly by 1840. The short 12-pounder was replaced by a long model about 1800.[38] There never seems to have been a short 32- or 42-pounder. Presumably the shorter weapon was found to have inadequate range, accuracy, and power with perhaps a more violent recoil because of its lightweight, while not protruding sufficiently out the ship's port.

The first models of the 12 and 18-pounder carronades may have had a slightly smaller, and the 42-pounder a slightly larger, bore diameter, than later weapons. These calibres may have been only experimental, although one notebook compiled in the first decade of the nineteenth century still recorded the earlier bore diameters for the 18- and 42-pounders.[39]

Bore Diameter

	1780	1800	difference
12 pdr.	4.50 in.	4.52 in.	+.02 in.
18 pdr.	5.14 in.	5.16 in.	+.02 in.
24 pdr.	5.68 in.	5.68 in.	-
32 pdr.	6.25 in.	6.25 in.	-
42 pdr.	6.85 in.	6.84 in.	-.01 in.
68 pdr.	8.05 in.	8.05 in.	-

Partly because of the method of mounting on the carriage by a loop cast underneath the barrel rather than by trunnions cast on the sides, the carronade was alleged to recoil violently and uncontrollably. When it was fired, it tended to rotate around the loop, the muzzle flying up and the breech smashing down, thus putting a great deal of strain on the carriage. The carronade was purposely designed with a loop " to enable it to project further from the Ships [sic] side than its want of length would otherwise have allowed."[40] This is not an entirely convincing explanation. An obvious solution to the problem was to cast trunnions on the carronade.

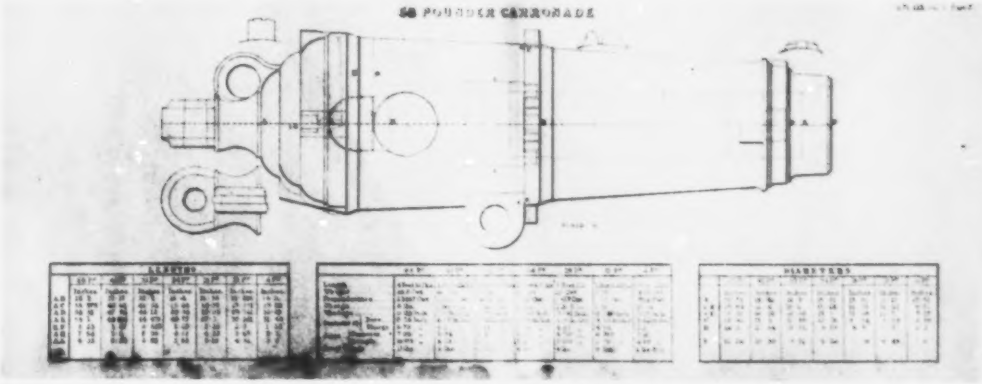


Figure 69. Carronades, circa 1850. (Boxer, Diagrams of Guns, Plate XXX.)

There are vague references in secondary literature to carronades with trunnions, but no mention was made of them in the various semi-official manuals that were published throughout the nineteenth century.[41] Examples, however, do exist. There is a 3-pounder at the Tower of London.[42] The National Maritime Museum, Greenwich, possesses a scale drawing of a 9-pounder.[43] Parks owns a 4-pounder, two 6-pounders, and two 18-pounders. They are similar in appearance to a carronade except that they have trunnions rather than a loop and they retain the standard gun button rather than the carronade's elevating screw box. In some cases the trunnions are centred, in others cast below the axis of the bore as was standard in gun design. The muzzles of some also had extra mouldings cast on. None of these appear to have been cast for official military or naval use, lacking the Board of Ordnance's identifying mark, the broad arrow (Figs. 70, 71, and 72).

There is a rather obscure reference in 1841. A Captain Hastings, a British naval officer who ended his career in the Greek service, wrote of

> Four long shorts (after drawings furnished by Captain Hastings), each 7 feet 4 inches long, weighing 58 cwt. with the form of a carronade in all but having trunnions to mount them, the same as long guns; but these trunnions are not placed as is usual in long guns, below the line for the quarter sights..., but so as to intersect the gun horizontally. These pieces of artillery were mounted on 10-inch howitzer carriages.[44]

Whatever these weapons were, they were very heavy, over 20 hundredweight more than a long 68-pounder carronade. It is also not clear if Hastings was writing of a British or a Greek vessel.

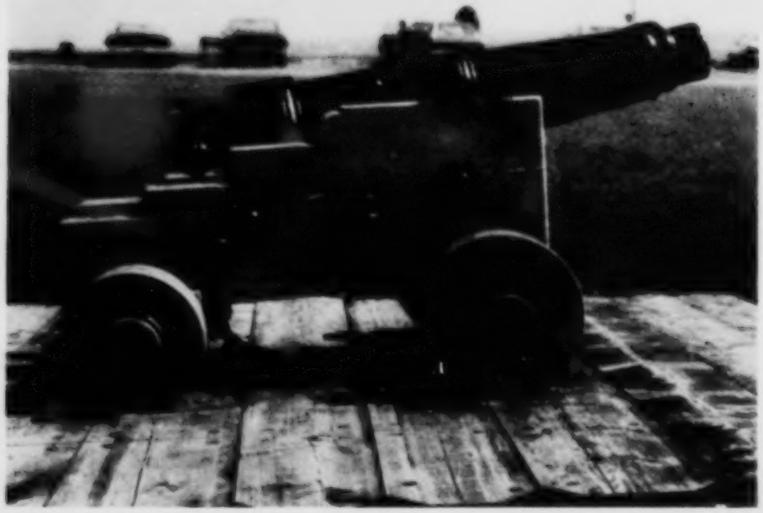


Figure 70. Carronade with trunnions, (calibre: 3.25 inches, 4-pounder ?), length: 3 feet. (Parks, Fort Beauséjour National Historic Park.)

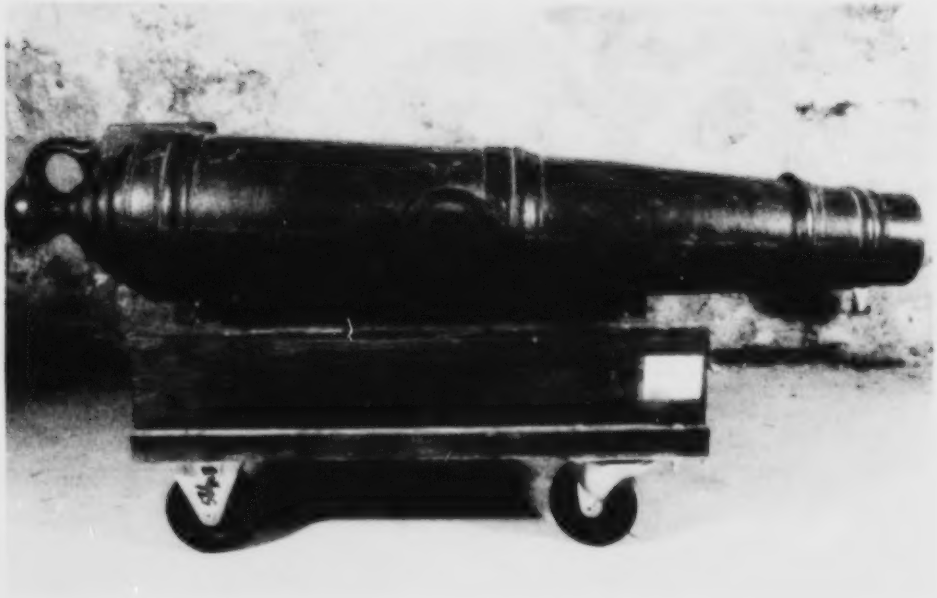


Figure 71. Carronade with trunnions (calibre: 3.55 inches, 6-pounder?), length: 3 feet 6 inches. (Parks, Lower Fort Garry National Historic Park.)

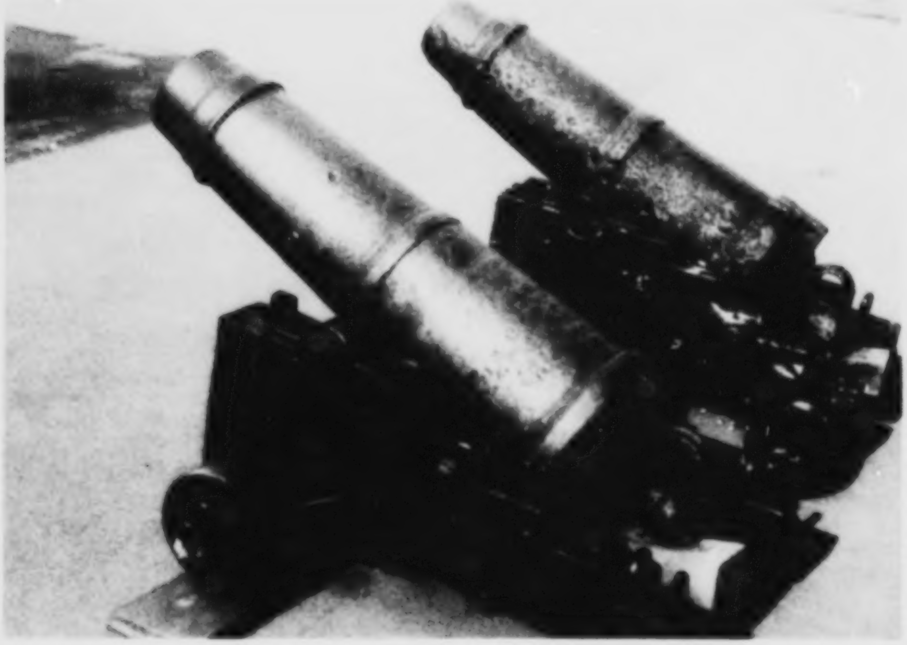


Figure 72. Two carronades with trunnions (calibre: 5.125 inches, 18-pounder?), weight: 18 hundredweight, length: 5 feet. (Parks, Fort George National Historic Park.)

MORTARS

Descended from the stubby, large-bore mediaeval bombards, mortars were relatively short, large-calibre artillery pieces designed to fire the largest, heaviest projectiles on the highest possible trajectories. Unlike guns which fired solid shot horizontally at high velocity, mortars fired shells or carcasses vertically at low velocity. Because the elevation usually was kept at 45 degrees in the British service, the range was altered by varying the strength of the service charge. Mortars depended for their destructive results not on the velocity of the projectile but on the explosive power and incendiary effects of their shells and carcasses. With their high angle of elevation, mortars could fire over obstacles to hit their targets and were consequently especially useful siege weapons. Occasionally the small, lighter mortars were used in the field.

Unlike guns or howitzers that were mounted on wheeled carriages, mortars were cast with their trunnions at the rear. Their carriages, called beds, were substantial blocks of wood hollowed out to receive the trunnions and breech of the mortar and designed to absorb the downward thrust of recoil when the mortar was fired. Unlike guns but like howitzers, mortars were chambered, that is the bore terminated in a compartment smaller than the calibre. This allowed the breech to have a greater thickness of metal to resist the power of discharges and to make the most efficient use (so it was argued) of the explosion of the service charge.

Brass Mortars

Coehorn Mortar

This small brass mortar was invented by the Dutch military engineer Baron Menno van Coehorn (or Cohorn, 1641-1704) and first used at the siege of Grâve in 1674.[1] The originals were made

> of hammer'd Iron of four inches diameter of the Bore, ten inches and a half long, and nine inches in the Chase, fixed upon a piece of Oak of 20 inches long, 10 and a half broad, and betwixt 3 and 4 thick; they stand fixed at 45 Degrees of Elevation and throw Hand Grenades as all other Hand Mortars do; they are placed in the bottom of the Trenches, at 2 yards distance from one another, having each a Soldier to serve it, and an Officer to every 40 or 50, who lays them to what Elevation he thinks convenient, by raising or sinking the hind part of the Bed; three or four hundred of them are sometimes in Service at once, in different parts of the Trenches, 60, 70, or 80 in a place.[2]

In the British service the Coehorn was cast in brass, it was slightly longer than its Dutch counterpart and it had a slightly larger bore.

The Coehorn appeared in a inventory at the Tower of London for the first time in 1713.[3] James, an artillery officer at the Tower, noted it about 1725, when it was said to be 1 foot 1 inch in length and to weigh slightly more than 1/2 hundredweight.[4] No other information was given. A Coehorn of the reign of King George II at the

Rotunda, Woolwich, described at 13.6 inches in length and 58 pounds in weight may approximate the mortar to which James referred (Fig. 73).[5]

Over the century and a half of its existence the Coehorn underwent changes in calibre, weight, dimensions, and the shape of its chamber. Although there is an example at the Tower of London from the reign of George II having a calibre of 4.5 inches, the early written sources gave its bore diameter at 4.6 inches and two specimens at the Rotunda Museum, Woolwich, have a calibre of 4.64 inches.[6] In 1764 when the Board of Ordnance revised the dimensions of pieces of artillery, it changed the Coehorn's calibre to 4.52 inches, at which it remained for the rest of its service life.[7]

Increases in weight and dimensions were probably related. A survey of the weight of these mortars from about 1725 to the 1860s reveals a gradual increase in weight from about 1/2 to almost 1 hundredweight, although the nominal weight was usually given as 3/4 hundredweight. This increase seems to have been caused mainly by an increase in the diameter of the mortar. A comparison of tables of dimensions from the 1750s, 1790s, and 1850s showed in each case that the diameter, and therefore the weight, had increased.[8]

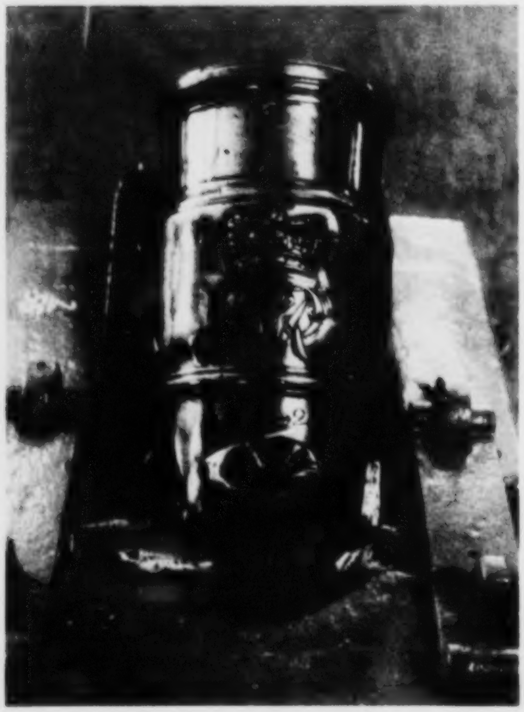


Figure 73. Brass Coehorn Mortar, cast in the reign of King George II (1727-60), weight: 2 quarters 24 pounds, length: 13.6 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/55.)

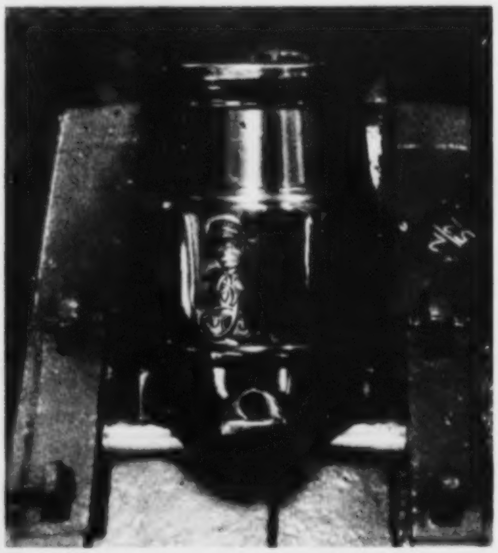


Figure 74. Brass Coehorn Mortar, cast in the reign of King George III (1760-1820), weight: 3 quarters 18 pounds. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, uncatalogued.)

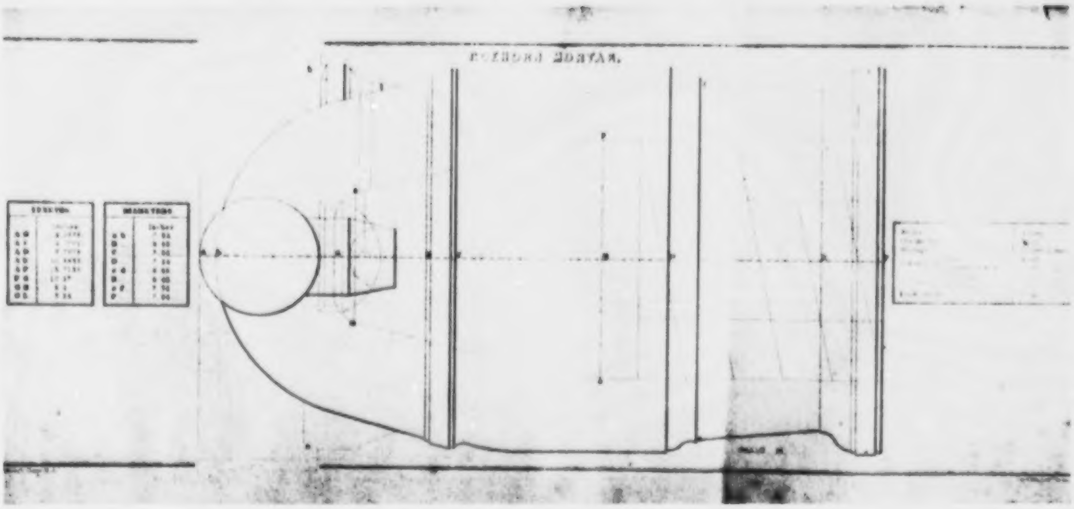


Figure 75. Brass Coehorn Mortar, weight: 1 hundredweight, length: 12.7125 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XXXIX.)

Another change, very minor, was the shortening of the mortar. After about 1750 its stated length was 1 foot 1 1/2 inches and it was so described by Rudyerd in 1791.[9] Probably in the first decade of the nineteenth century, perhaps earlier, it was shortened slightly to 12-3/4 inches, at which length it was to remain.[10]

A more radical change was the replacement of a slightly conical chamber by the Gomer chamber. In the 1750s Glegg gave the dimensions of the conical chamber:

length	3.7 inches
greatest diameter	2.7 inches
least diameter	1.4 inches

In 1791 Rudyerd recorded a shorter, less tapering version:

length	3.35 inches
greatest diameter	2.2 inches
least diameter	1.55 inches[11]

The conical chamber was connected to the bore by a semi-hemisphere corresponding to the exterior of the shell.

The Gomer chamber was also a truncated cone but it merged directly into the bore of the mortar. It took its name from a French officer, Louis-Gabriel de Gomer (1718-98), who successfully incorporated this chamber into a mortar in the mid-1780s.[12] It was later adopted by other European powers. Blackmore in his inventory of ordnance at the Tower of London recorded a Gomer chamber in a Coehorn mortar cast in 1814, but it may have been adopted as early as the 1790s.[13]

Royal Mortar

The history of the Royal Mortar is very similar to that of the Coehorn, although its origins are more obscure. It is not known when the Royal was introduced into service but James included a reference to it in his notebook about 1725 and it was first included in an inventory of the Tower of London in 1726.[14] Nor is it known why it was called Royal; Blackmore cited a reference from Belgium in 1716 referring to "mortiers royals" and suggests that the term originally may have been French.[15] Two examples of these early Royal Mortars from the reign of King George I are at the Rotunda, Woolwich (Fig. 76).[16]

Like the Coehorn, the Royal underwent changes during its lifetime to its calibre, weight, dimensions, and, although this is less clear, to the shape of its chamber. The calibre of the early Royals was 5.8 inches; this is the measurement given by the earliest written source, Glegg, in the 1750s, and the Royals at the Rotunda were measured at 5.73 inches, a difference that is hardly significant.[17] When the Board of Ordnance revised the dimensions of mortars in 1764 the calibre was changed to 5.62 inches at which it was to remain throughout the remainder of its career.[18]

The weight of the Royal was increased during its service life. About 1725 James gave its weight at 1 hundredweight 4-1/2 pounds.[19] Thereafter in the eighteenth century it was usually recorded at 1-1/4 hundredweight while in the next century it was usually about 14 pounds heavier.[20] This increase in weight was caused probably by increases in the diameter of the mortar. A comparison of tables of dimensions, circa 1750, 1791, and circa 1850, shows, as with the Coehorn, that at each period the diameter and thus the weight had increased.[21]

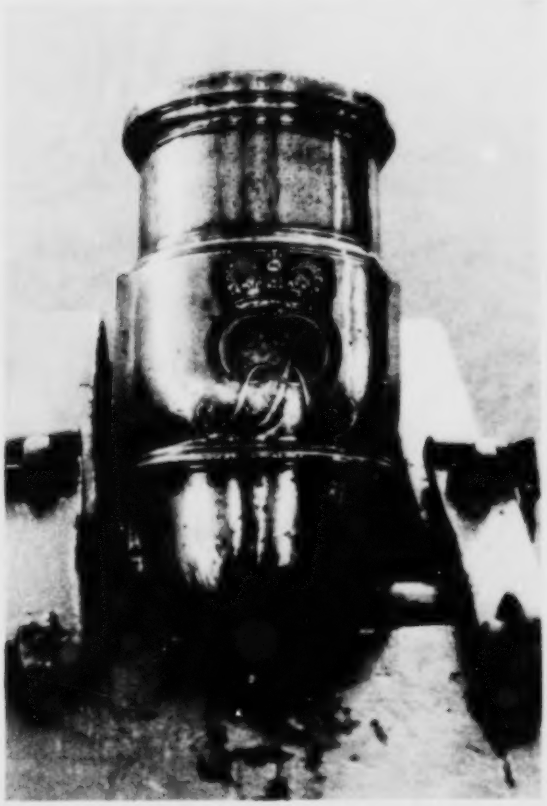


Figure 76. Brass Royal or 5 1/2-inch Mortar, cast in the reign of King George I (1714-27), length: 15.2 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/35.)

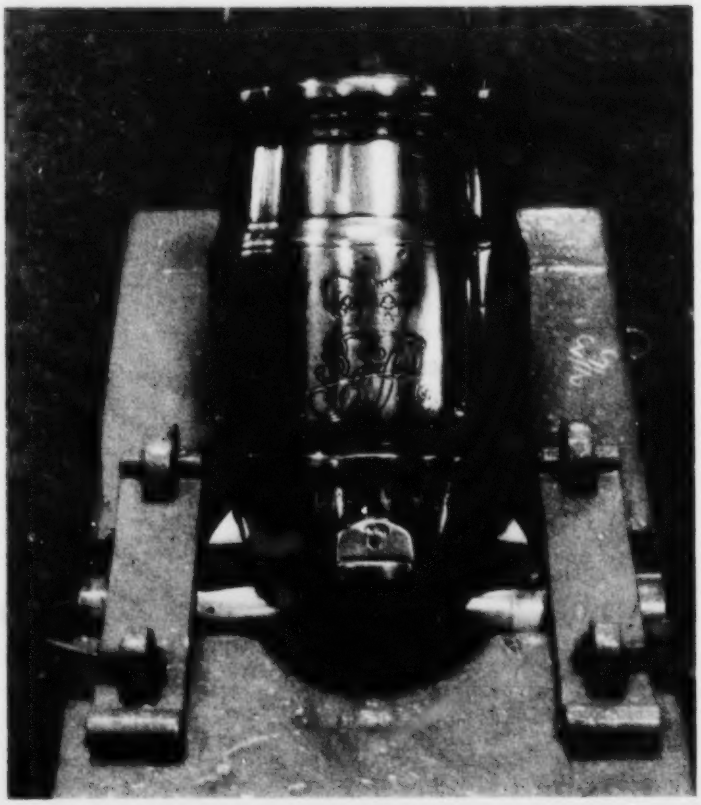


Figure 77. Brass Royal or 5-1/2-inch Mortar, cast by Francis Kinman in 1794, weight: 1 hundredweight 1 quarter ? pounds. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, uncatalogued.)

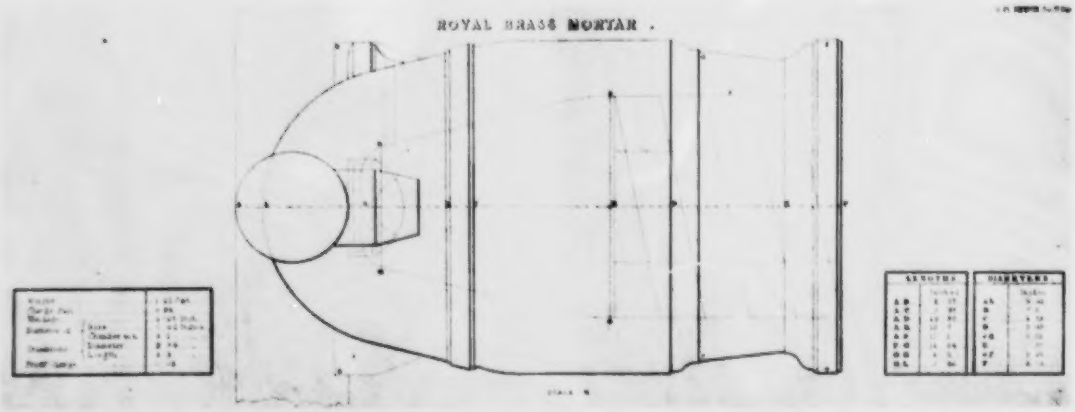


Figure 78. Brass Royal or 5-1/2-inch Mortar, weight: 1.25 hundredweight, length: 15.1 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XXXVIII.)

The Royal also underwent slight variations in length. About 1725 James set down its length at 15.5 inches, in the 1750s Glegg had it at 16.5 inches, in 1764 the Board of Ordnance reduced it to 16 inches, and in 1791 Rudyerd recorded it at 16.265 inches.[22] Although Adye in 1801 and 1813 indicated that the length was 16.25 inches, Blackmore has recorded four Royals of this period at the Tower of London all with lengths of 15 inches.[23] The most precise measurement of its length stated in subsequent manuals is 15.1 inches.[24] It seems likely that Adye's manual was out of date and that the change in length took place in the 1790s.

Originally the Royal had a conical chamber. In the 1750s Glegg gave its dimensions as

length	4.5 inches
greatest diameter	3.0 inches
least diameter	2.4 inches

In 1791 Rudyerd recorded a slight change in size and shape:

length	4.05 inches
greatest diameter	2.85 inches
least diameter	2.05 inches

The conical chamber, as in the case of the Coehorn gave way to the Gomer chamber. It is reasonable to conclude that this happened at the same time that it did in the case of the Coehorn, which possibly was as early as the 1790s (see above). Blackmore did not mention a Royal with a Gomer chamber until 1859, but Spearman in his 1828 manual gave dimensions of the chamber which indicated that it was of the Gomer shape.[26]

8-Inch Mortar

About 1725 James noted an 8-inch brass mortar in his book. Its length was 2 feet 2 inches and its weight 4 hundredweight.[27] Unfortunately no other dimensions were given, nor are there any examples extant at either the Tower of London or the Rotunda, Woolwich. The first table of dimensions in Glegg's notebook of the 1750s gave the length at 25.5 inches, that is 1/2 inch shorter than James's specification. The weight was about the same, 4 hundredweight 20 pounds.[28] Quite likely there would be no significant difference between a 8-inch mortar of 1725 and one of 1750.

According to Smith the length and weight of the 8-inch mortar established by the Board of Ordnance in 1764 was 2 feet 2 inches and 4 hundredweight.[29] In 1791 when Rudyerd made his drawings, the length given was 25.75 inches and, compared to the Glegg table, there were certain other differences in lengths and diameters, most notably in the diameter of the reinforce.[30] Glegg gave the diameter of the reinforce at 15.4 inches while Rudyerd stated it to be 11.4 inches. In the latter case this equalled the diameter of the muzzle ring, an equality usual in land service mortars. In Glegg's table the muzzle was said to be 11.2 inches in diameter, much smaller than the reinforce. It is possible that Glegg has erred in recording the reinforce diameter. In any case a comparison of the dimensions listed by Glegg and those by Rudyerd indicates that there were some changes in detail between about 1750 and 1791.

In his manuals of 1801 and 1813, Adye listed the 8-inch brass mortar at 25.75 inches in length and at slightly more than 4-1/4 hundredweight in weight; in all likelihood this was the mortar drawn by Rudyerd (Fig. 79).[31] At variance with this design is that of four 8-inch brass mortars, three of 1805 and one of 1808, in the Tower of London. Whereas Rudyerd's mortar had a reinforce, these have lost it and are consequently shorter, being 1 foot 8.5 inches long. On the other hand, they weigh more, about 6-1/2 hundredweight (Fig. 80).[32] It seems clear that Adye's manual was out of date and that the newer model, as in the case of the Royal and Coehorn, had been introduced during the 1790s.

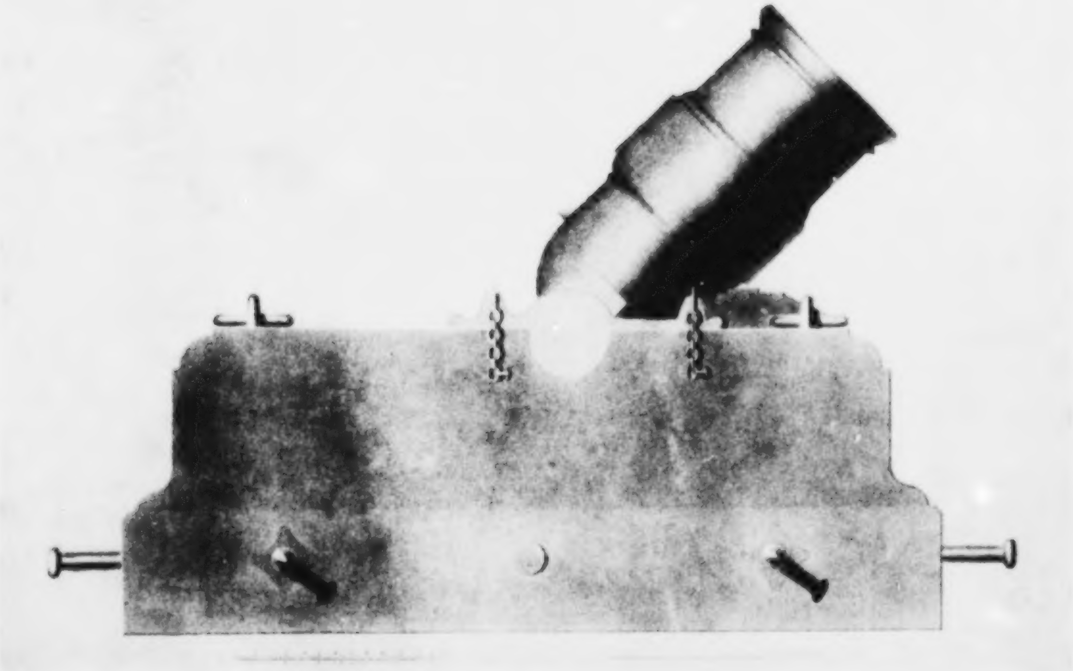


Figure 79. Brass 8-inch Mortar and Bed, circa 1820. (Cf. Rudyerd drawing.) (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

Figure 80. Brass 8-inch Mortar and Bed. (Collection of the Armouries, H.M. Tower of London. Reproduced by kind permission of the Trustees of the Armouries. See Blackmore, pp. 100-1, No. 110.)

The 8-inch brass mortar reached the end of its career probably during the Napoleonic Wars. In 1825 a student at the Royal Military Academy noted that it was obsolete, although it continued to be recorded in one manual until the end of the 1850s.[33] Boxer did not include it in his series of drawings, circa 1850, nor was it listed in the tables of the Aide-Mémoire. It may have been lengthened slightly being listed at 1 foot 9 inches and 1 foot 9-1/2 inches in length. Straith included a diagram of it in his Plans of 1841, in which its length was given at 1 foot 9-1/2 inches and its weight at 6-1/2 hundredweight. The diagram resembles very closely the examples at the Tower of London.[34]

There is extant in the Tower of London an 8-inch bronze (brass) mortar of a different design dated 1865. It was composed of two parts, breech and chase, but the latter was longer and consequently the total length of the mortar was 2 feet 10.5 inches. According to the Inventory its weight was 3 cwt. 1 qr. 16 lb., which seems remarkably light, about one-half the weight of the older and shorter model. This design of mortar was not mentioned elsewhere; it may perhaps have been an experimental model, as suggested by the N° 1 stamped on the end of the right trunnion.[35]

10-Inch Mortar (Land Service)

The 10-inch land service brass mortar had been in service well before the beginning of the eighteenth century.[36] In 1725 James gave some details in his notebook — 2 feet 9 inches long and weighing almost 10 hundredweight.[37] A quarter of a century later Glegg compiled the dimensions of an 8-inch mortar, of the same length but weighing 10-1/2 hundredweight.[38] The Board of Ordnance regulations of 1764 left the length the same, 2 feet 9 inches, but increased the weight once again to 11 hundredweight.[39] Mortars of both of the latter weights were referred to in practice tables during the 1770s and 1780s.[40] The mortar drawn by Rudyerd in 1791 matched the length and weight of the one specified in 1764.[41] A comparison of the dimensions set down by Glegg and Rudyerd indicate slight increases in the diameters of the latter, but the most notable change was in the shape of the chamber. Glegg gave the dimensions as

length	7.8 inches
greatest diameter	4.5 inches
least diameter	3.6 inches

Rudyerd specified a longer, less tapering chamber:

length	8.5 inches
greatest diameter	4.75 inches
least diameter	4.0 inches

It is likely that the history of the 10-inch brass land service mortar paralleled that of the 8-inch, becoming shorter and heavier; unfortunately the evidence is not so clear since there are no examples extant at the Tower of London or at the Rotunda, Woolwich. Although in 1801 and 1813 Adye referred to a 10-inch brass land service mortar of 2 feet 9 inches and almost 10-1/2 hundredweight, there is some evidence that he was again out of date.[42] According to the Aide-Mémoire the weight of the 10-inch mortar about 1790 was 12-3/4 hundredweight.[43] There was also the reference in 1795 or 1796 to ordnance "Upon the old Construction," including the 10-inch mortar of 11 hundredweight, which implied a "new" construction.[44] In 1827, Adye cited an example of 12-3/4 hundredweight, and Griffiths in his manuals from 1839 to 1859 included a 10-inch mortar of 2 feet 3 inches weighing 12-1/4 hundredweight.[45] Since Boxer did not include a drawing of it in his collection of plans, nor was it included in the tables of dimensions in the Aide-Mémoire it is reasonable to conclude that it was obsolete by the 1840s, indeed probably a number of years previous.

13-Inch Mortar (Land Service)

Brass 13-inch land service mortars were certainly in use before 1700. The Gentleman's Dictionary referred to them in 1705 and James noted a 13-inch brass mortar about 1725, although he does not specify whether land or sea service.[46] In the 1750s Glegg set down detailed dimensions, noting its length at 3 feet 7 inches and its weight at 25 hundredweight.[47] According to Smith, the regulations of the Board of Ordnance of 1764 specified the same weight but a length of 3 feet 8 inches.[48] Other sources in the 1770s and 1780s also recorded this length, but there is extant a 13-inch brass land service mortar on loan from the Tower to the Royal Arsenal, Woolwich, which, while weighing 25 hundredweight, was measured at 3 feet 7 inches.[49]

In 1791 Rudyerd included in his notebook the drawing and dimensions of a 13-inch land service mortar of a length of 43.6 inches and a weight of 25 hundredweight.[50] Its dimensions, except for the chamber, were very similar to those recorded by Glegg. The bore was slightly shorter and the chamber slightly longer and more tapered. Glegg gave dimensions of:

length	12 inches
greatest diameter	6.6 inches
least diameter	6 inches

Rudyerd recorded them as:

length	12.6 inches
greatest diameter	6.5 inches
least diameter	4.9 inches

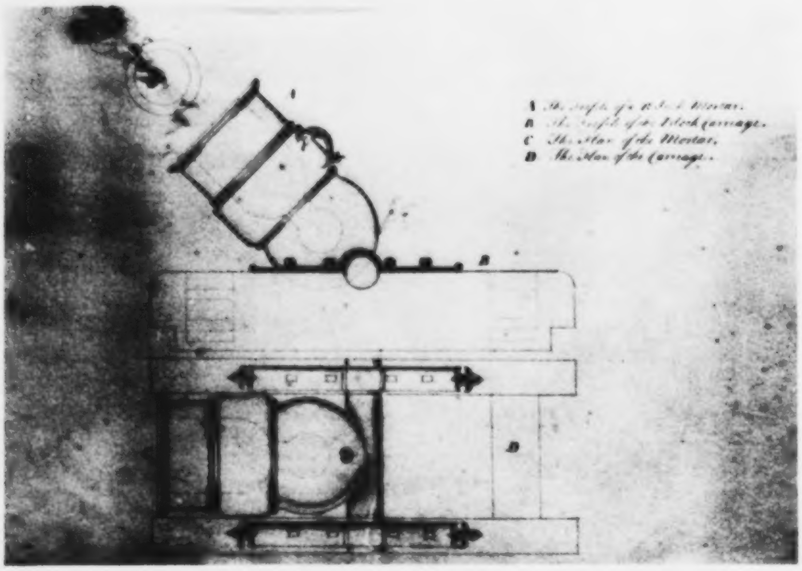

A
B The Profile of the Block Carriage.
C The Plan of the Mortar.
D The Plan of the Carriage.
A
B

Figure 81. Brass 13-inch Mortar and Bed, circa 1710. (The Royal Artillery Institution, Woolwich, U.K., Borgard, "Practiss of Artillery.")

A comparison of Rudyerd's drawing with one made by Adye in 1766 showed that, except for the adoption of an ovolo in 1791 rather than a ogee behind the reinforce, the general design and the arrangement of mouldings of the two mortars was the same.[51]

In his manuals in 1801 and 1813 Adye recorded the 13-inch brass land mortar at 3 feet 7-1/2 inches and 25 hundredweight, very similar to Rudyerd's specifications. About 1820 Shuttleworth made a drawing of a 13-inch mortar which appears to be very similar to Rudyerd's (Fig. 82).[52] By 1825 Mould recorded the weight at 27-3/4 hundredweight but declared it to be obsolete.[53] Thereafter there was no mention of it. Possibly, like the 8- and 10-inch mortars it had been redesigned in the same manner, becoming shorter and heavier, but no examples, drawings nor detailed specifications exist to verify this speculation.

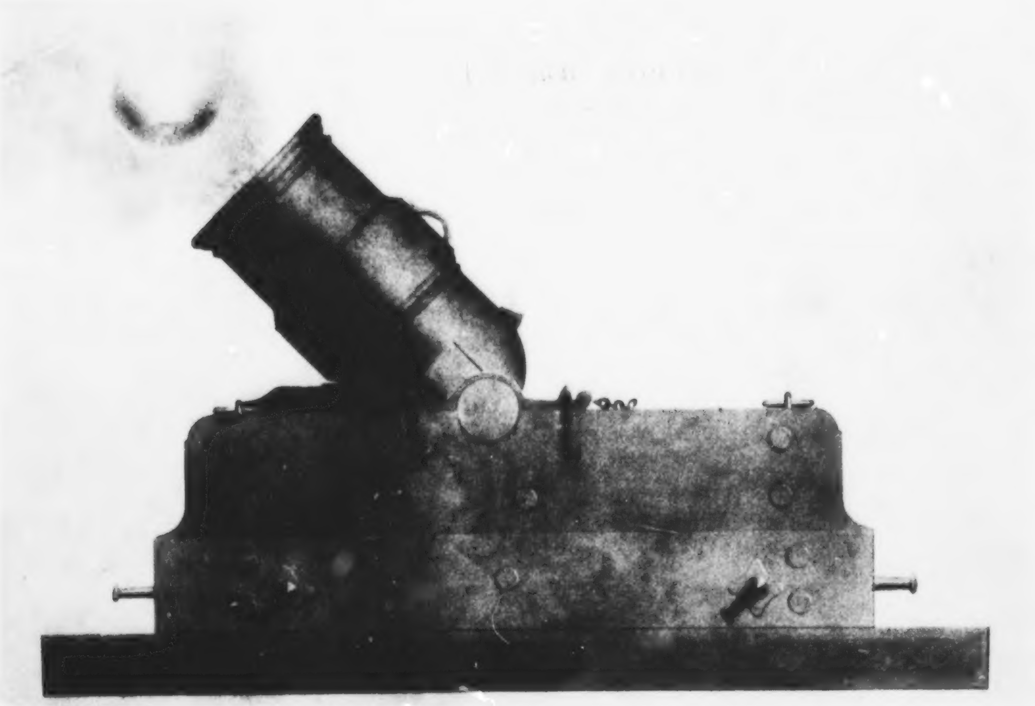


Figure 82. Brass 13-inch Mortar and Bed, circa 1820. (Cf. Rudyerd drawing.) (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

10-Inch Mortar (Sea Service)

It is difficult to say when the 10-inch brass sea service mortar was first brought into service. According to The Gentleman's Dictionary of 1705 sea service mortars were usually 13 inches in calibre.[54] The lesser calibre was certainly in existence by the 1750s when Glegg set down its dimensions.[55] It was 56 inches in length and weighed 32 cwt. 3 qr. 7 lb. According to Smith, in 1764 the Board of Ordnance specified that the length was to be 57 inches and the weight 33 hundredweight.[56] In 1791 Rudyerd made a drawing of a mortar with a length and weight matching that of Glegg.[57] A close examination of the two sets of dimensions indicate that they were very similar, except for the chambers. Glegg gave the following dimensions:

length	15 inches
greatest diameter	6.6 inches
least diameter	6.0 inches

Rudyerd showed a longer but more tapering chamber:

length	15.8 inches
greatest diameter	6.5 inches
least diameter	4.5 inches

The last mention of the 10-inch brass sea service mortar, 56 inches in length and weighing 33 hundredweight, occurred in Adye's manual of 1813.[58] Quite likely it was already obsolete.

13-Inch Mortar (Sea Service)

The brass 13-inch sea service mortar was described in The Gentleman's Dictionary in 1705:

> Sea Mortars ... generally 13 inches diameter of the Bore, is longer and more reinforced than a Land Mortar, because they are fired with a greater quantity of Powder, sometimes with 30 or 33 pounds; some of them have their Beds or Stools of Metal cast in a piece with the Mortars, others have them of a thick square piece of Oak, which by the help of Handscrews or Jacks is turned round upon a strong Axis of Iron to fire any way; they are always fixt at an Elevation of 45 degrees; they carry Bombs of 200 pound and generally weigh about 9 or 10 000 weight [i.e. about 80 or 90 hundredweight].[59]

There is in the Tower of London a 13-inch brass mortar cast by Andrew Schalch in 1726 which fits this description (Fig. 83). It is 5 feet 3 inches in length, weighs almost 81-3/4 hundredweight, and its reinforce is of a greater diameter than its muzzle.[60]

There are no detailed specifications of Schalch's mortar, but a comparison between a drawing of it and drawings made by Muller and Adye indicated a very close resemblance; indeed they appeared identical. According to Glegg, Muller, and Adye the mortar was 5 feet 3 inches long and weighed 81 hundredweight 1 quarter 18 pounds, a difference in weight of no great significance.[61] According to Smith, in 1764 the Board of Ordnance established the length at 5 feet 3 inches and the weight at 82 hundredweight.[62] In 1791 Rudyerd's drawing and specification were very similar to those of the 1750s, although there were some minor variations. The length and weight were the same. As in the case of the other mortars the major change was in the chamber. In the 1750s its dimensions were:

length	21 inches
greatest diameter	8.5 inches
least diameter	7 inches

In 1791, Rudyerd specified a slightly longer, wider, and more tapered chamber:

length	21.55 inches
greatest diameter	9.6 inches
least diameter	6.8 inches

The latest reference to this mortar occurred in Adye's manual of 1813.[63] Quite likely it was obsolete by this time.

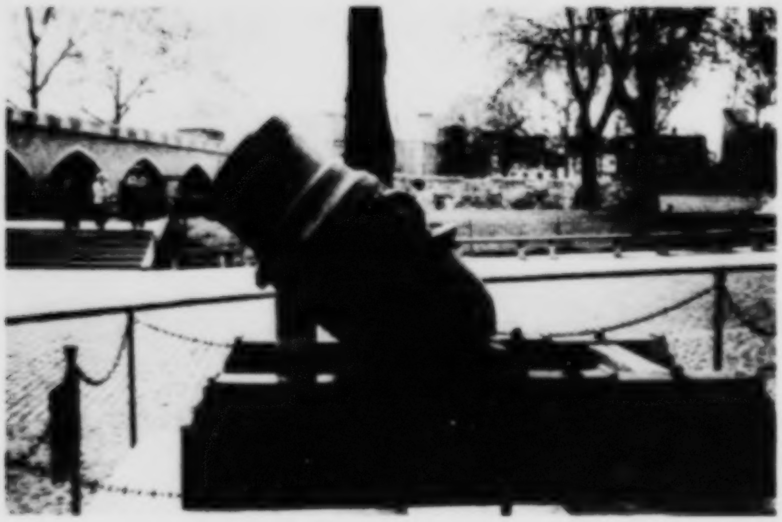


Figure 83. Brass 13-inch Mortar and Bed, cast by Andrew Schalch in 1726, weight: 81 hundredweight 2 quarters 24 pounds, length: 5 feet 3 inches. (Collection of the Armouries, H.M. Tower of London. Reproduced by kind permission of the Trustees of the Armouries. See Blackmore, pp. 97-8, No. 102.)

Iron Mortars

In the first decade of the nineteenth century, two systems of iron land service mortars were in existence. One of these, probably the older, was recorded in the "Notes" of Samuel Parlby in 1804.[64] In an article on iron mortars, Adrian B. Caruana argues that mortars of this system were being used in practice as early as 1794. The other system, while not recorded in student notebooks until the 1820s, clearly dated from before 1810; Caruana offers evidence that mortars of this pattern were used in a practise at Woolwich in 1797. The precise dates of origin of these two systems remains the subject of speculation, however, although Caruana, citing student notebooks from the late 1820s and 1830s, suggests that the second system originated partly in 1780 and partly in 1786.[65] A third system of iron land service mortars was introduced alongside the second, probably in the late 1830s or early 1840s.

8-Inch Mortar (Land Service)

The 8-inch iron mortar of the early system was 2 feet [illegible] inches long and weighed 7-3/4 hundredweight, according to Parlby. Its structure was similar to that of brass mortars – a cascable, reinforce, and chase, with an assortment of rings, fillets, and ogees. It was constructed with the old long, narrow, slightly conical chamber.[66]

The other 8-inch iron mortar of the early period was 1 foot 10 inches long and weighed 8 hundredweight. (Later sources indicated that it was 1 foot 10-1/2 inches long and weighed 8-1/2 hundredweight.) It was more simply designed, lacking a reinforce, and it was bored with a Gomer chamber (Figs. 84 and 85).[67]

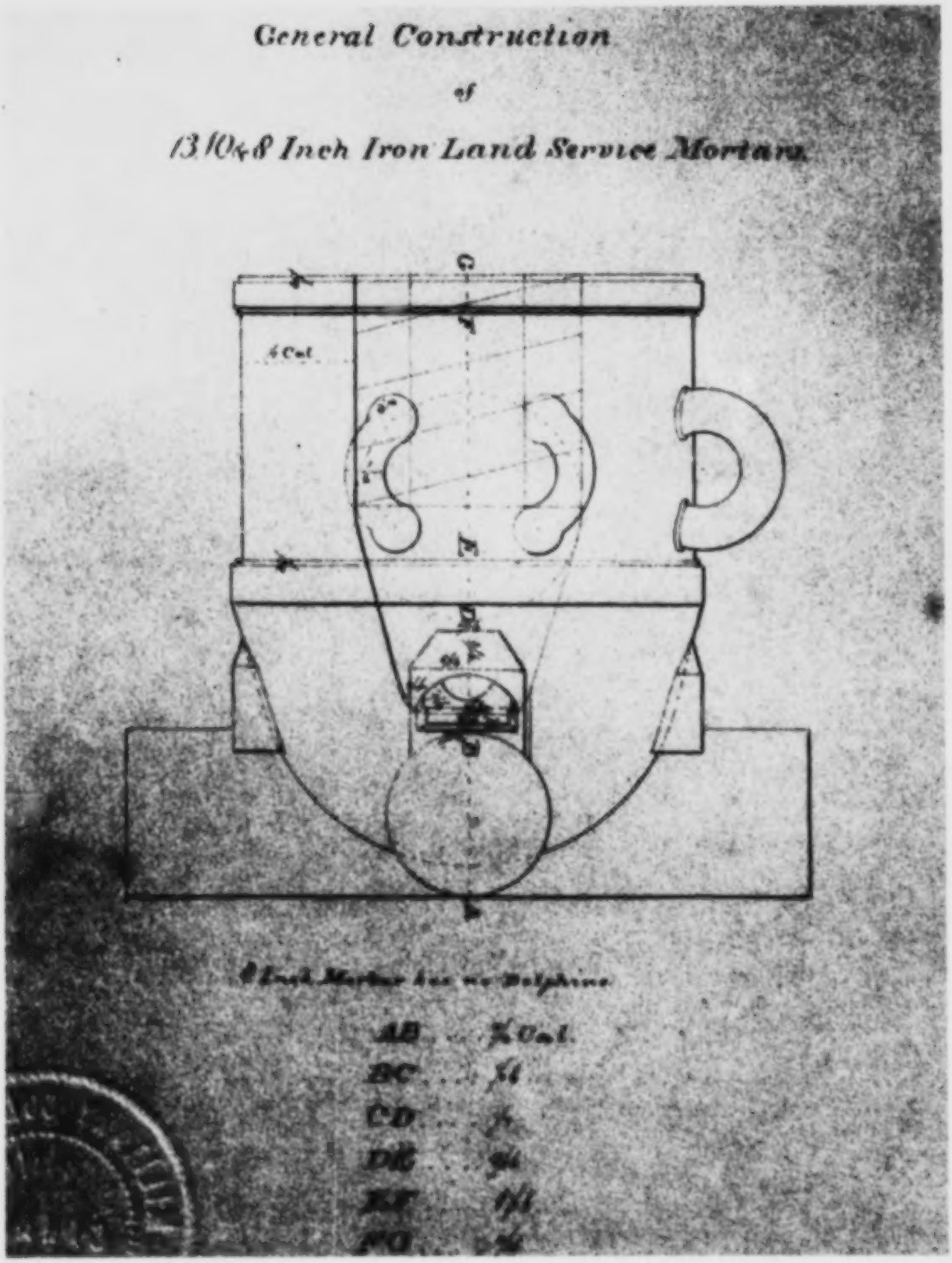

General Construction
of
13 10 & 8 Inch Iron Land Service Mortars
4 Cal.
G
F
E
D
A
8 Inch Mortar has no Dolphins
AB ... Cal.
BC ...
CD ...
DE ...
EF ...
FG ...

Figure 84. General Construction of 13-, 10-, and 8-inch Land Service Mortars, circa 1825. (Royal Military College, Mould, p. 100.)

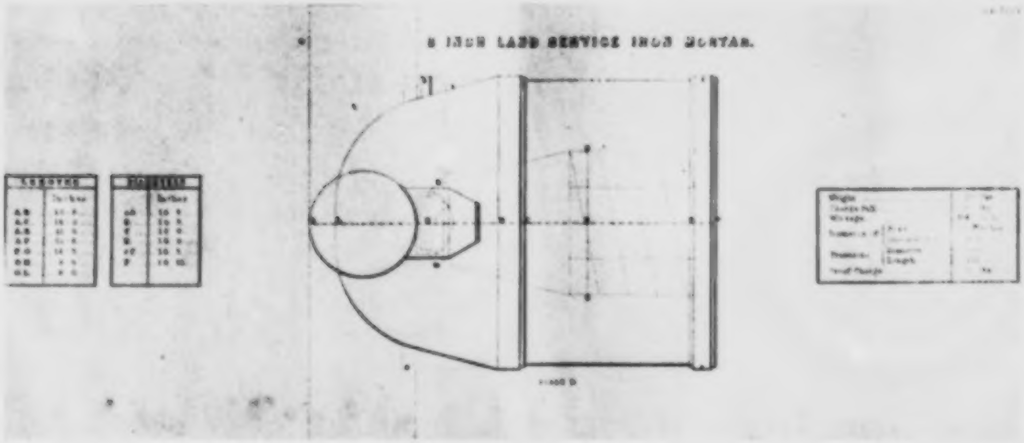


Figure 85. Iron 8-inch Land Service Mortar, weight: 8.5 hundredweight, length: 22.5 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XXXVI.)

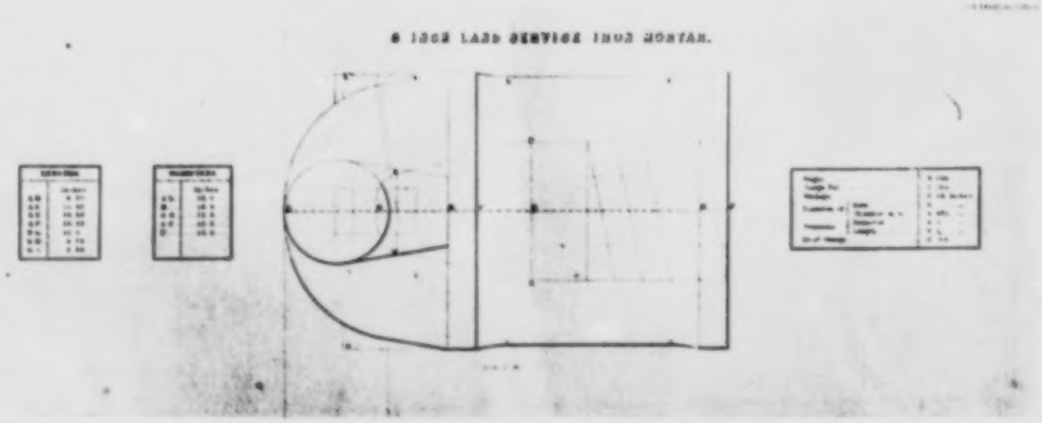


Figure 86. Iron 8-inch Land Service Mortar, weight: 9 hundredweight, length: 25.23 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XXXVII.)

In the 1840s a second 8-inch iron mortar, longer and slightly heavier at 2 feet 1-1/4 inches and 9 hundredweight, was added to the service (Fig. 86).[68] The chase was lengthened, the fillets around the rings were removed and a flat vent patch, to which a firing lock could be attached, was added.

Both mortars remained in service, but the newer model obviously was to supersede the older. In 1852 it was recommended that the former be included in the armament of coast batteries.[69] By 1857 there were 35 in use and 78 in store. Two years later it was recommended that the older model, of which 95 were in store, be declared obsolete.[70] This recommendation was carried out in 1865.[71] The newer model was still in service as late as 1881.[72]

10-Inch Mortar (Land Service)

The history of the 10-inch iron land service mortar duplicates that of the 8-inch. In 1804 Parlby recorded its length at 2 feet 10.37 inches and its weight at 15-1/2 hundredweight. Like its smaller sister it had a similar design, decoration, and chamber.[73] The 10-inch mortar of the second system was 2 feet 3.5 inches long and weighed 16 hundredweight. (Caruana cites a number of sources giving the length at 2 feet 4 inches; Boxer in the 1850s has it at 2 feet 3.125 inches and weighing 17 hundredweight.) It was bored with the Gomer chamber and it was cast with dolphins (Figs. 84 and 87).[74]

In the 1840s a longer model of 2 feet 7.53 inches and about 28 hundredweight was brought into service (Fig. 88).[75] The chase had been lengthened, a flat vent patch added, and the fillets had been removed from around the rings. It retained the Gomer chamber but it was no longer cast with the dolphins of the earlier model. By the end of the 1850s the shorter version was no longer in use but the 18 hundredweight mortar was regarded as "... a serviceable piece for siege trains."[76] It was still in service in 1881.[77]

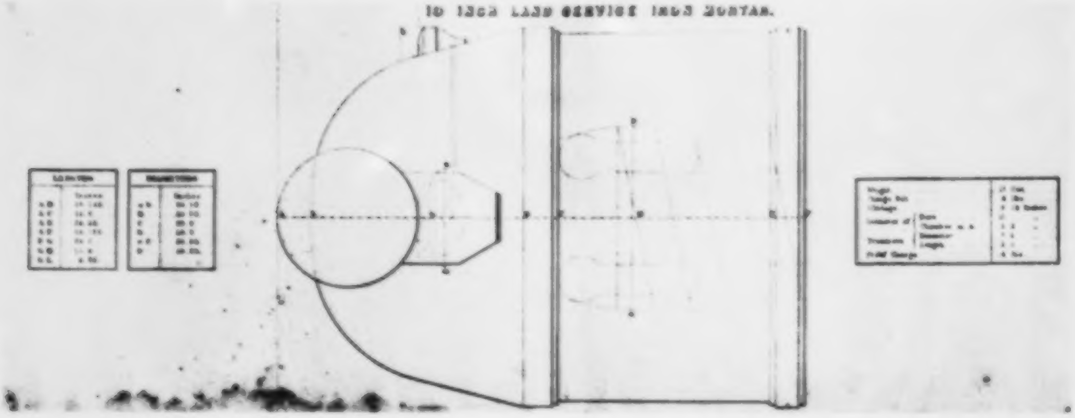


Figure 87. Iron 10-inch Land Service Mortar, weight: 17 hundredweight, length: 28.125 inches, circa 1850. (Boxer, Diagram of Guns, Plate XXXIV.)

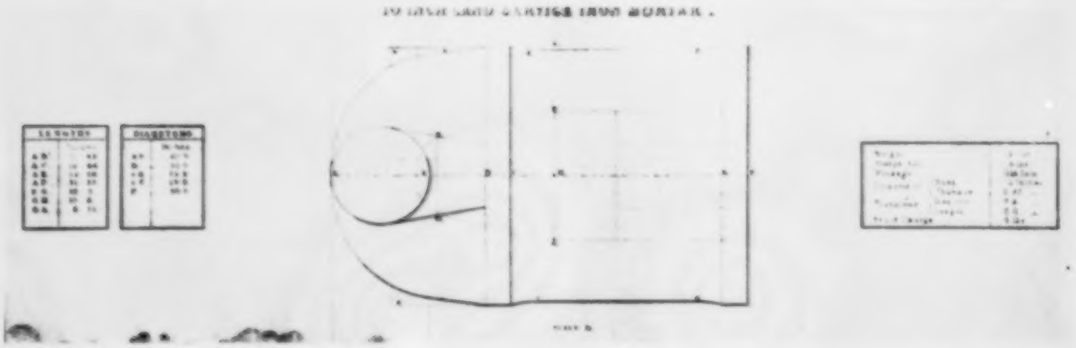


Figure 88. Iron 10-inch Land Service Mortar, weight: 18 hundredweight, length: 31.53 inches, circa 1850. (Boxer, Diagram of Guns, Plate XXXV.)

13-Inch Mortar (Land Service)

The history of the 13-inch land service iron mortar varies slightly from that of the 8-inch and 10-inch. In 1804 Parlby recorded two 13-inch mortars – one 3 feet 9.5 inches long and weighing 34-1/4 hundredweight and the other almost the same length, 3 feet 8.6875 inches, but considerably heavier at 37 hundredweight 3 quarters 1 pound. According to Caruana the decorations were similar on both, but the longer mortar was cast with considerably less metal, especially around the chamber.[78] There are two 13-inch mortars in the Tower of London both listed at 3 feet 9.5 inches in length, weighing 38 hundredweight and 38-3/4 hundredweight. Their dates are estimated at 1830, but while not matching exactly, their appearance is very similar to the system that Parlby recorded in 1804 (Fig. 89).[79]

According to the general construction of the second system of land service iron mortars of this early period given in Mould's notebook of 1825, the 13-inch of this system would be 2 feet 9.75 inches long. Caruana cites a number of sources from 1827 to 1839 giving the length at 3 feet and the weight at 36 hundredweight. There are two examples of this calibre and construction of mortar in the Tower of London. One, which is known to have been proofed in 1808, is 3 feet 0.5 inches long and weighs 3.5 hundredweight 3 quarters 17 pounds; the other is the same length but weighs 36 hundredweight 12 pounds (Fig. 89). This pattern was cast with a Gomer chamber and dolphins. It seems to have passed from favour quite early, for, while there are references to it in the 1840s, it was not listed in the Aide-Mémoire nor did Boxer include it in his series of drawings in the 1850s.[80]

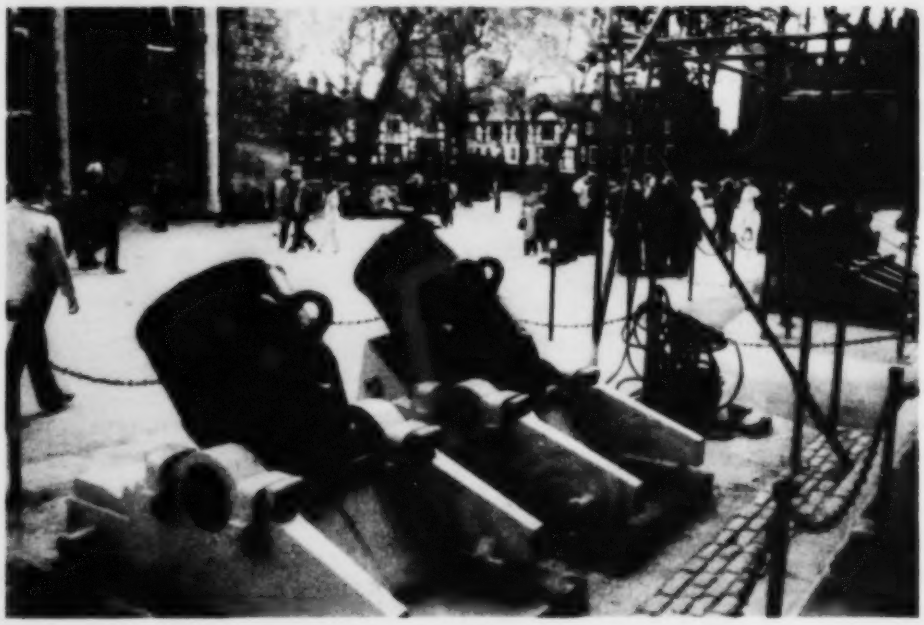


Figure 89. Two iron 13-inch Mortars. The longer wights 38 hundredweight and is 3 feet 9.5 inches long; the shorter weights 35 hundredweight 3 quarters 17 pounds and is 3 feet 0.5 inches long. (Collection of the Armouries, H.M. Tower of London. Reproduced by kind permission of the Trustees of the Armouries. See Blackmore, pp. 102-5, Nos. 113 and 119.)

In the 1840s a slightly longer model of 3 feet 3.65 inches, weighing 36 hundredweight, was introduced into service (Fig. 90). As was true of the 8- and 10-inch mortars, the 13-inch mortar lost its dolphins and the fillets around the ring but it retained the Gomer chamber and added a flat vent patch. The chamber had changed slightly in size, its length and greatest diameter remaining at 13 inches but its least diameter increasing from 7.5 to 7.6 inches.[81] This pattern continued in service and, by the 1860s, was "... used in siege operations as well as permanent batteries, and is provided with a travelling carriage for its transport in siege trains."[82] It was still on the active list of ordnance in 1881.[83]

Along with land service mortars, there were also sea service mortars which were used on gun ketches or in coastal fortifications. These were longer, heavier weapons than the land service mortars. (Only the 10- and 13-inch mortars were designed for sea service; there is no record of an 8-inch sea service mortar.) The evidence indicates that between about 1790 and the 1860s there were in service two variations on one pattern (probably designed by Sir Thomas Blomefield). The difference between the two variations was an increase in the weight of each calibre of mortar; the appearance remained the same.

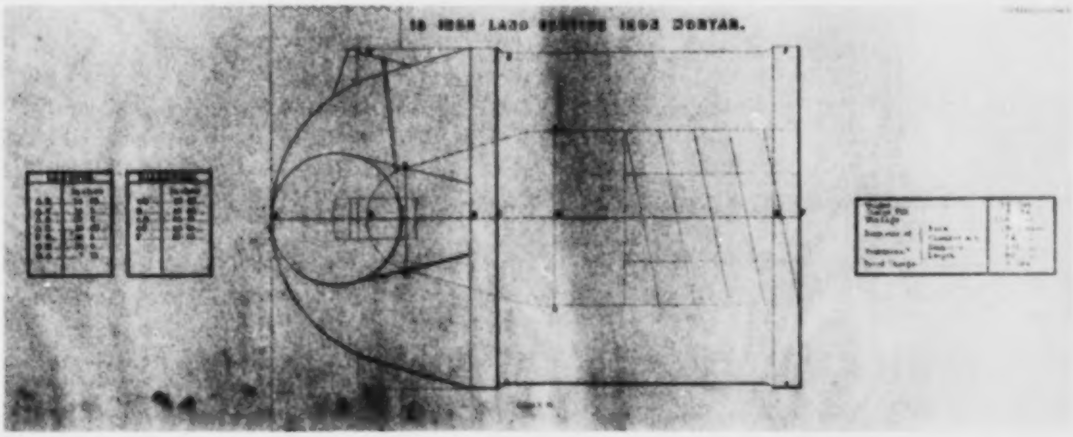


Figure 90. Iron 13-inch Land Service Mortar, weight: 36 hundredweight, length: 39.65 inches, circa 1850. (Boxer, Diagram of Guns, Plate XXXIII.)

10-Inch Mortar (Sea Service)

According to Miller the 10-inch iron sea service mortar was first cast in 1790.[84] The earliest written evidence of such a mortar occurs in a notebook attributed to R.W. Adye, circa 1800, which gives the general construction of two patterns, one of 5-1/2 calibres (4 feet 7 inches) and weighing 47-1/2 hundredweight, the other of 4-1/2 calibres (3 feet 9 inches) and weighing 42 hundredweight (Fig. 92).[85] The Parlby notebook of 1804 gave similar dimensions: a 10-inch long sea service mortar of 4 feet 7.6 inches and 47-1/2 hundredweight and a short pattern of 3 feet 9.6 inches and 42 hundredweight.[86] As well, at Quebec City there are two 10-inch mortars cast by Carron in 1798, both within fractions of an inch of 4 feet 7 inches in length, one weighing 47 hundredweight 2 quarter 14 pounds and the other 47 hundredweight 3 quarters 4 pounds (Fig. 91). In appearance they match the patterns reproduced by Adye and by Caruana.[87]

Also in Quebec City there is a 10-inch mortar 3 feet 10 inches in length and weighing 52 hundredweight 13 pounds which was cast by Carron in 1813 (Fig. 94).[88] This agrees closely with the length of the pattern given in Mould's notebook in 1825 – 4-9/16 calibres. Mould's 1825 pattern looks the same as the circa 1800 pattern but the former has considerably more metal around the bore.[89] According to the Adye notebook, circa 1800, the mortar was designed by Sir Thomas Blomefield; the heavier version is clearly only a variation of the lighter. The heavier pattern continued to be mentioned in various manuals, but in 1864 Miller noted that "sea service piece has been but little employed in late years." It was still listed in service in 1881.[90]

The sea service mortar did not adopt the Gomer chamber but retained the long, narrow, slightly conical variety. There were certain modifications in it, however. Spearman in 1828 gave its dimensions:

length	10 inches
greatest diameter	7.5 inches
least diameter	5.64 inches[91]

By 1850 this chamber had been lengthened and slightly widened:

length	11.68 inches
greatest diameter	7.5 inches
least diameter	5.75 inches.[92]

Another variation was the loss of dolphins in the 1850s. Although Boxer's diagram still showed the dolphins (Fig. 95), an example of the mortar in Quebec city, cast by Walker and Co. in 1855, which in most other external respects appears to be identical to the 1813 example, is lacking them.[93] Also there is no vent patch on the later mortar; the vent is drilled directly through the breech (Fig. 96).[94]

Figure 91. Iron 10-inch Sea Service Mortar, cast in 1798 by the Carron Company, weight: 47 hundredweight 2 quarters 14 pounds, length: 4 feet 7 inches. One of a pair. (Parks, rue des Remparts, Québec.)

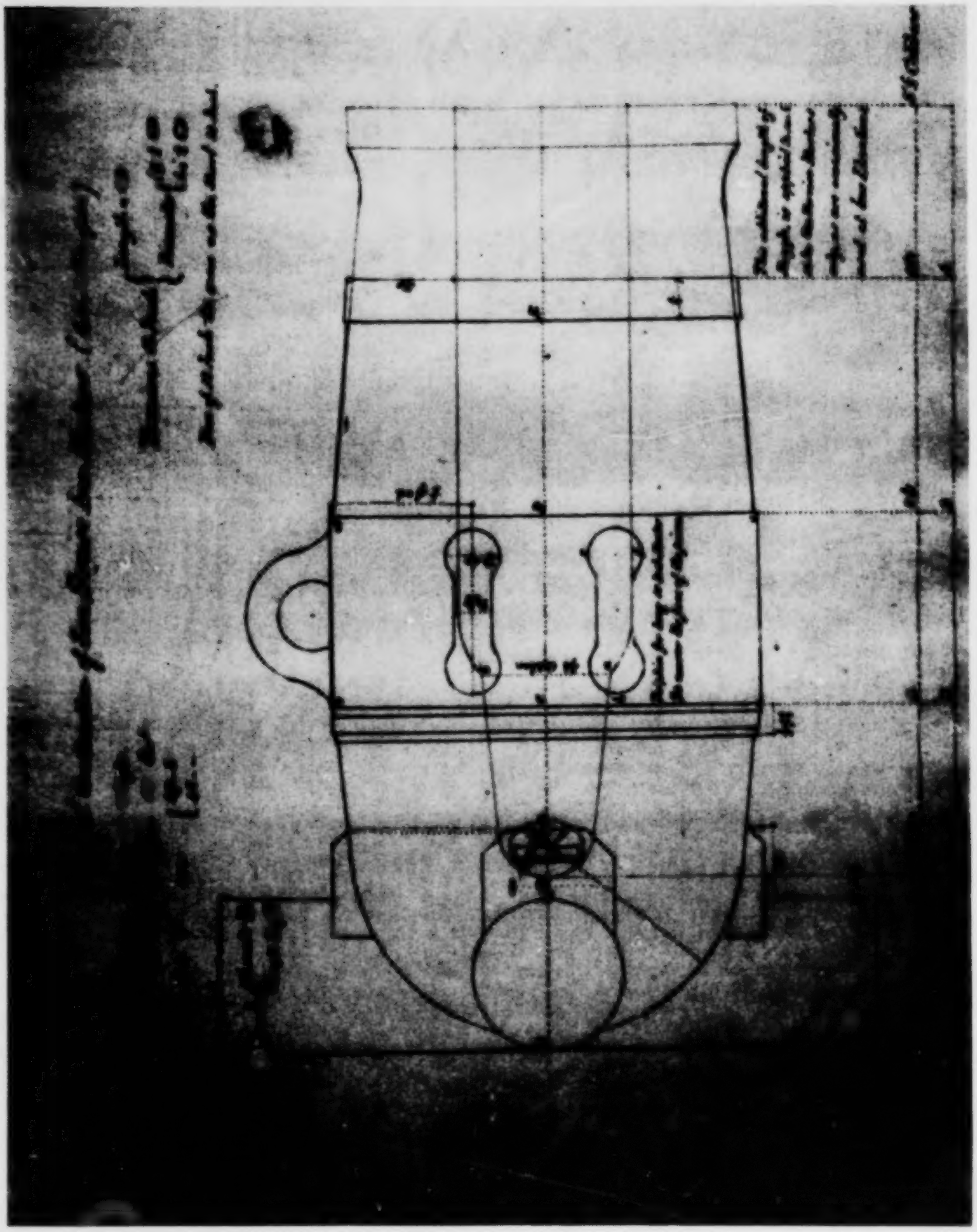


Figure 92. General Construction of Sea Service Iron Mortars (Colonel Blomefield). (Parks, Fort Malden National Historic Park, Adye, Notebook, circa 1800.)

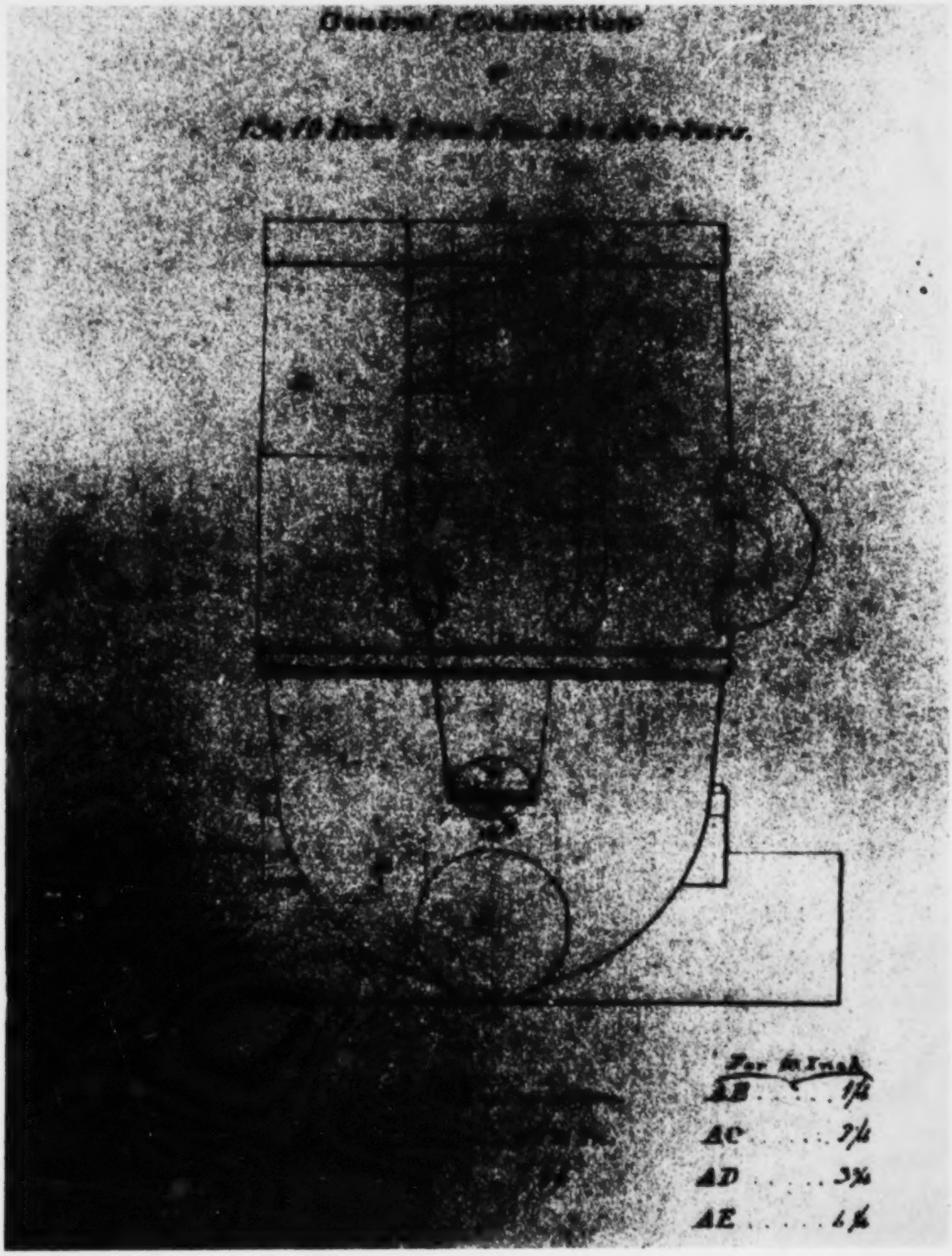

General Construction
13 & 10 Inch Iron Sea Service Mortars.
For 10 Inch
AB
AC
AD
AE

Figure 93. General Construction of 13-and 10-inch Iron Sea Service Mortars, circa 1825. (Royal Military College, Mould, p. 101.)

13-Inch Mortar (Sea Service)

The history of the 13-inch iron sea service mortar was similar to the 10-inch. Its pattern was first outlined circa 1800 in the Adye notebook; it was 4 calibres or 4 feet 4 inches long and weighed 82 hundredweight (Fig. 92).[95] The Parlby notebook of 1804 confirms both the length and weight.[96]

A slightly longer, 4 feet 4.8125 inches, and much heavier model, 100 hundredweight, was first cast in 1810.[97] Its construction was outlined in Mould's notebook of 1825 (Fig. 93).[98] Boxer included it in his drawings in the 1850s (Fig. 97).[99] The only difference between the two versions appears to have been in the size of the chamber. In 1828 its dimensions were:

length	13 inches
greatest diameter	9.75 inches
least diameter	7.312 inches.[100]

Boxer showed a longer slightly wider chamber:

length	15.14 inches
greatest diameter	9.75 inches
least diameter	7.5 inches.[101]

This mortar was used in the Crimea during the siege of Sebastopol in 1855. In 1861 it was recommended for the armament of coast batteries.[102]

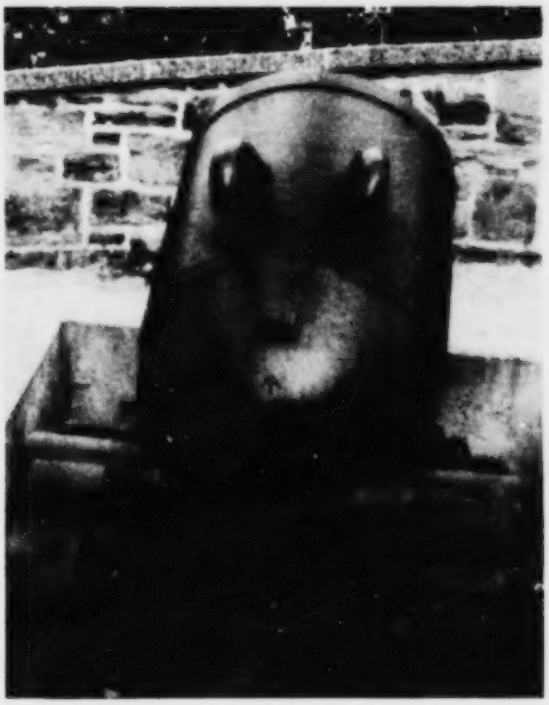


Figure 94. Iron 10-inch Sea Service Mortar, cast in 1813 by the Carron Company, weight: 52 hundredweight 13 pounds, length: 3 feet 10 inches. (Parks, rue des Remparts, Québec.)

A number of 13-inch iron sea service mortars burst or were rendered unserviceable during the bombardment of Sweaborg on the Baltic in 1855. This misfortune prompted a series of tests into the nature of the metal and the methods of construction of mortars.[103] Perhaps because of these investigations the mortar was redesigned and a new model accepted into the service in February 1862. The new mortar weighed the same but it was longer, 5 feet 4 inches, with a windage of 0.1 inch rather than .16 inch of the old model. It no longer was cast with dolphins.[104] Both versions were still on the active list in 1881.[105]

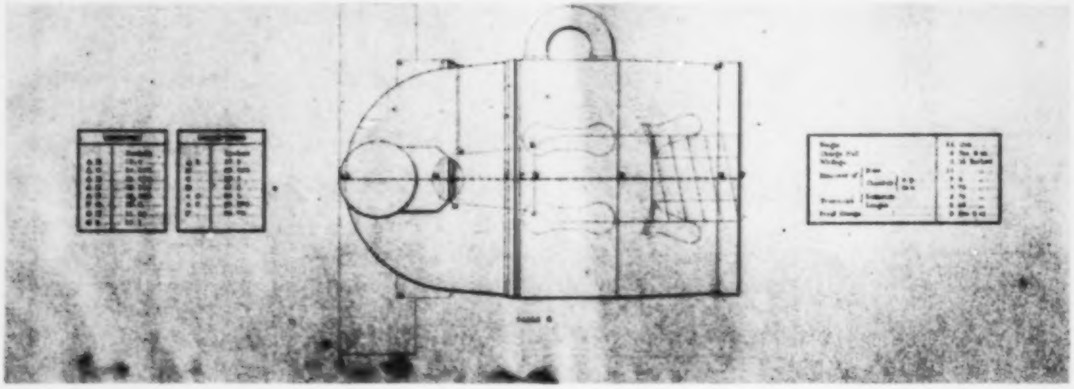


Figure 95. Iron 10-inch Sea Service Mortar, circa 1850. (Boxer, Diagrams of Guns, Plate XXXII.)

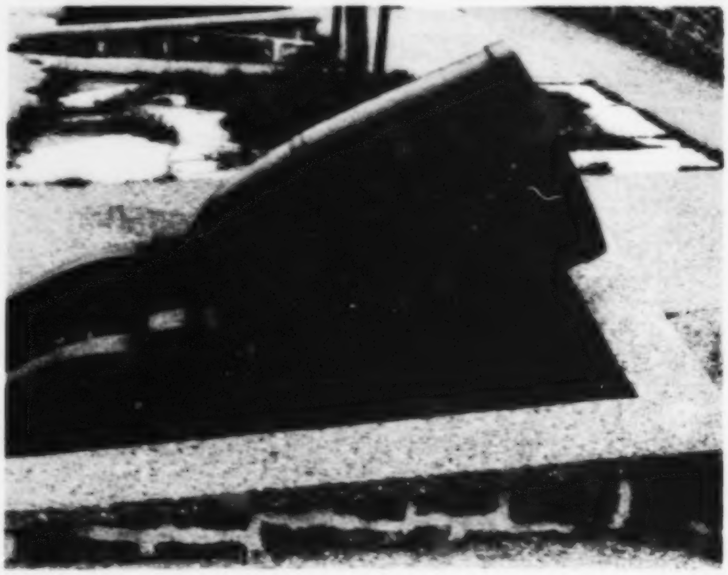


Figure 96. Iron 10-inch Sea Service Mortar, cast in 1855 by the Walker Company, weight: 52 hundredweight 1 quarter 8 pounds, length: 3 feet 9.5 inches. (Parks, rue des Remparts, Québec.)

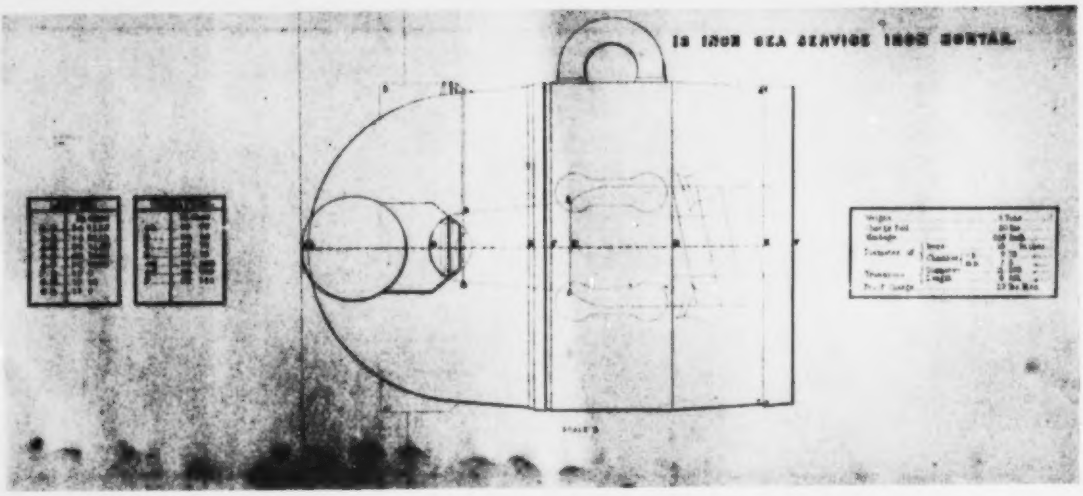

13 INCH SEA SERVICE IRON MORTAR.
Weight

Figure 97. Iron 13-inch Sea Service Mortar, circa 1850. (Boxer, Diagrams of Guns, Plate XXXI.)

HOWITZERS

A howitzer was a cross between a gun and a mortar. Like a mortar it was a large calibre weapon designed to fire shells or carcasses, but it was neither so heavy nor so immobile. Longer than a mortar but shorter than a gun, it was cast with trunnions like a gun, enabling it to be mounted on a wheeled carriage. Designed to fire its projectiles on high trajectories, although not as extreme as a mortar's, it could fire over the heads of friendly troops or over obstacles to hit its target. Its bore was chambered like a mortar's and for the same reasons. Howitzers were used both as siege weapons and in the field. The first howitzers, both siege and field, were cast of brass. But following the Napoleonic wars iron siege howitzers were introduced, and longer brass howitzers, shaped more like guns, replaced the old, short howitzers in the field service.

Brass Howitzers

Coehorn Howitzer

The Coehorn Howitzer was essentially the Coehorn mortar designed for field service. It came into use sometime before 1750. Hughes, in his study of British smooth-bore artillery says it was first cast in 1728 but he does not cite his source.[1] A treatise on artillery published in 1881 claimed that it was introduced in 1738.[2] According to a note in the Aide-Mémoire it was in service by 1750.[3] In 1764 the Board of Ordnance set out its dimensions — calibre, 4.52 inches; length, 1 foot 10 inches; weight 2 hundredweight and 14 pounds.[4] Over the next quarter century there were references to a howitzer of this length and about this weight, but no drawings or detailed specifications have been found until Rudyerd's series of drawings made at the Royal Military Academy in 1791.[5] It seems likely that the howitzer he depicted had not changed significantly since 1764 or even before. The weight was not stated but the length was 21.95 inches, an insignificant difference of 0.05 inches. Like its mortar counterpart, the Coehorn howitzer's bore ended in a slightly conical chamber:

length	4.52 inches
greatest diameter	2.73 inches
minimum diameter	2.24 inches

In the 1790s the early pattern was replaced by a newer version of the Coehorn howitzer, an example of which, cast in 1811, is extant at the Rotunda, Woolwich (Fig. 98).[6] The museum catalogue gives the calibre at 4.52 inches, the length at 1 foot 10 inches, and the weight at 2-1/2 hundredweight, but the design has been somewhat simplified. The chase astragal and fillets have vanished and the first and second reinforces are joined by an ogee rather than by an astragal and fillets. The chase tapers towards the muzzle but both reinforces now seem to be true cylinders unlike those of the earlier model. The button and neck of the cascable have been shortened. A thick vent patch through which the vent was drilled has been cast on the first reinforce.

This piece closely resembles a drawing of a Coehorn howitzer made in 1819 by Shuttleworth, a student at the Royal Military Academy (Fig. 99). Its length was given at 22.6 inches (that is 5 calibres) and its weight at 2 hundredweight 1 quarter 14 pounds "nearly." The lengths and diameters of the various parts were stated quite clearly. The only peculiarity of the drawing was its portrayal of the cascable; in it the ogee leading from the base ring to the neck of the button is drawn as a short cylinder. This is at variance with the 1811 example and with later drawings. It may be no more than an error in draughting.[7]

This is the pattern of mortar described in the later manuals and portrayed in drawings in the late 1840s. It is probably this pattern which Mould, in his notebook in 1825, described "For Colonial Service in difficult roads and with Mountain Artillery." In 1828 Spearman gave the length at 22.6 inches, slightly longer than the 1811 example, but an exact 5 calibres. He also noted dimensions which indicated that the chamber was no longer slightly conical, but, rather, cylindrical:

length	4.8 inches
greatest diameter	2.26 inches
least diameter	2.26 inches.[8]

There are two later drawings of this pattern, one by a student at the RMA in the late 1840s (Fig. 100) and the other by Boxer in his series of plates published in 1853 (Fig. 101).[9] A comparison indicates certain minor differences. The howitzer in the student's drawing is 22.6 inches long; Boxer's is shorter, 22.38. There are also certain proportional differences in the lengths of the reinforces and chase, but the diameters are the same. The chamber is also slightly longer in Boxer's drawing, 5.1025 inches, but its diameter remained the same, 2.26 inches. It seems then that about 1850 the Coehorn howitzer underwent certain minor changes in design.

That there were two Coehorn howitzers by about 1845 is supported by the tables in the Aide-Mémoire which list two patterns, one called "light" and the other "Coehorn."[10] These tables record the chamber sizes mentioned above, and agree as well in the diameters that are identical. But the lengths of the two patterns do not agree with the lengths given either by the student or Boxer. It is difficult to believe that there were four variations, albeit minor, of the Coehorn howitzer by the mid-1840s. The only other detailed drawing and measurement which has been found occurred in a treatise in 1881; it almost duplicated Boxer's drawings and dimensions.[11] Probably it is best to view the Aide-Mémoire's dimensions with suspicion.

The Coehorn howitzer, originally designed for the field service, was replaced by Millar's 12-pounder brass howitzer in the 1820s, but it continued in use for mountain and colonial service. As late as 1881 it was still included on the active list.[12]

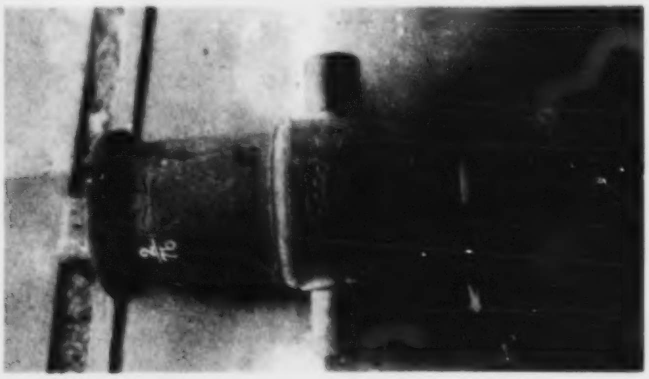


Figure 98. Brass Coehorn Howitzer, cast in 1811, weight: 2 hundredweight 2 quarters, length: 1 foot 10 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/76. This piece appears to have been misnumbered II/78; in the catalogue it does not correspond to the description of II/78 but rather of II/76.)

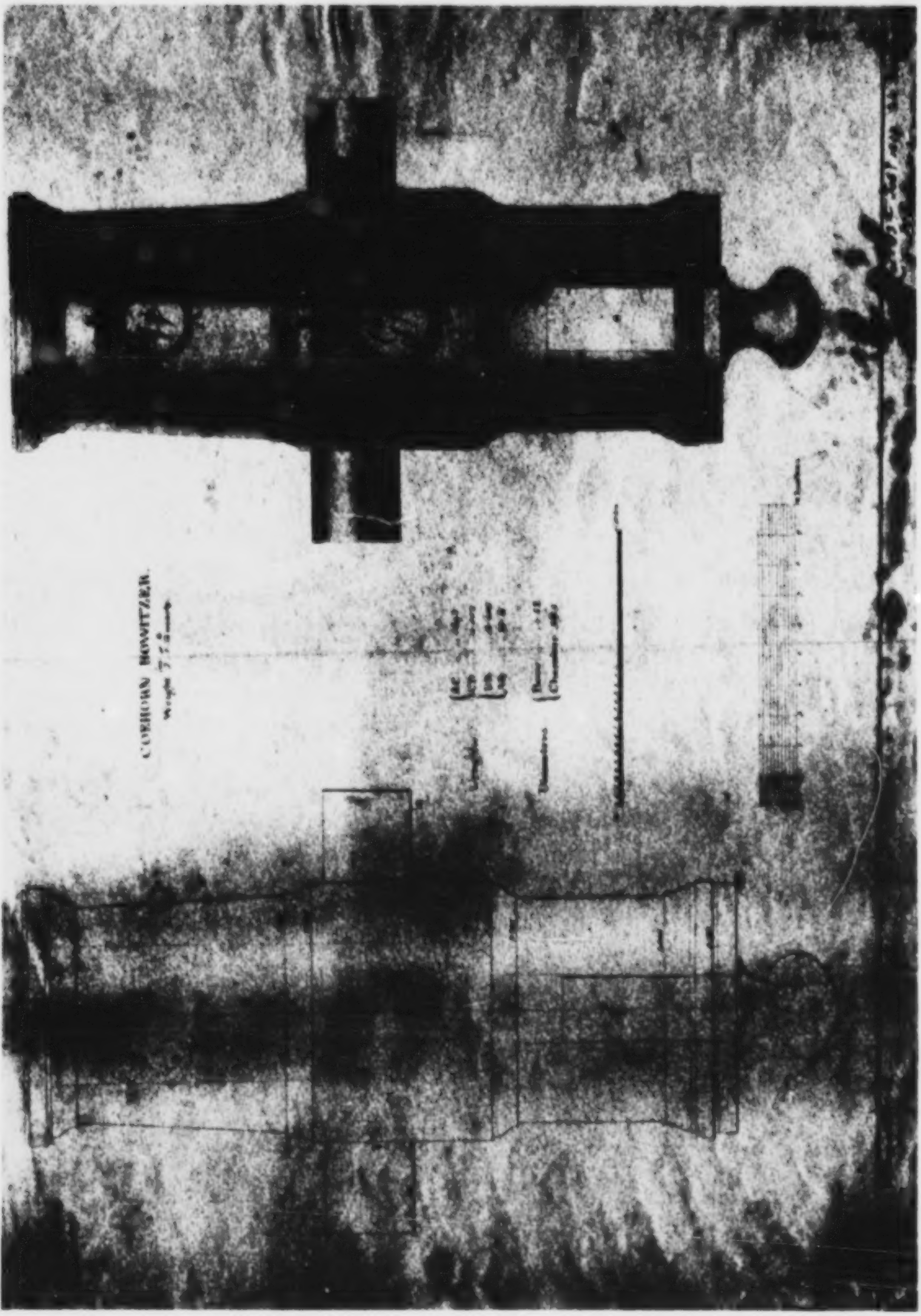

COEHORN HOWITZER
Weight 7 7 8

Figure 99. Brass Coehorn Howitzer, circa 1820 (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

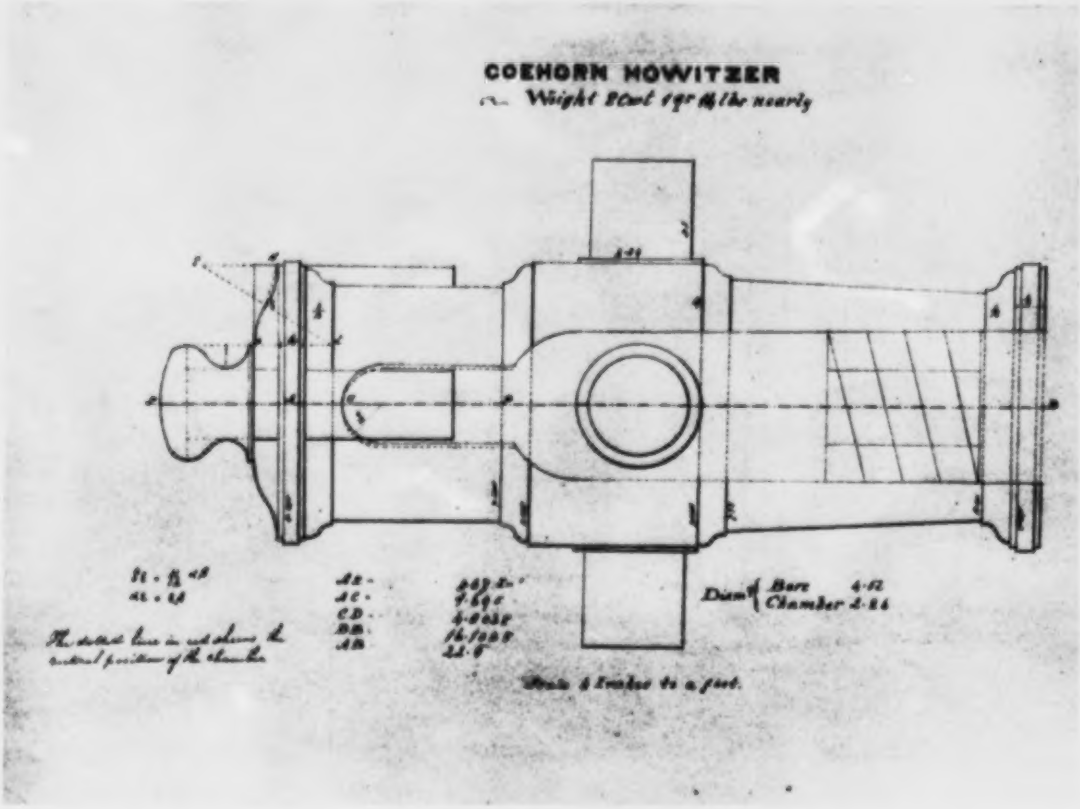

COEHORN HOWITZER
Weight 2cwt 1qr 14lbs nearly
The dotted line in red shews the natural position of the chamber
AE
AC
CD
DB
AB
Diam{ Bore 4·52
Chamber 2·24
Scale 6 Inches to a foot.

Figure 100. Brass Coehorn Howitzer, circa 1850. (The Royal Artillery Institution, Woolwich, U.K., Strange, "Drawings on Artillery.")

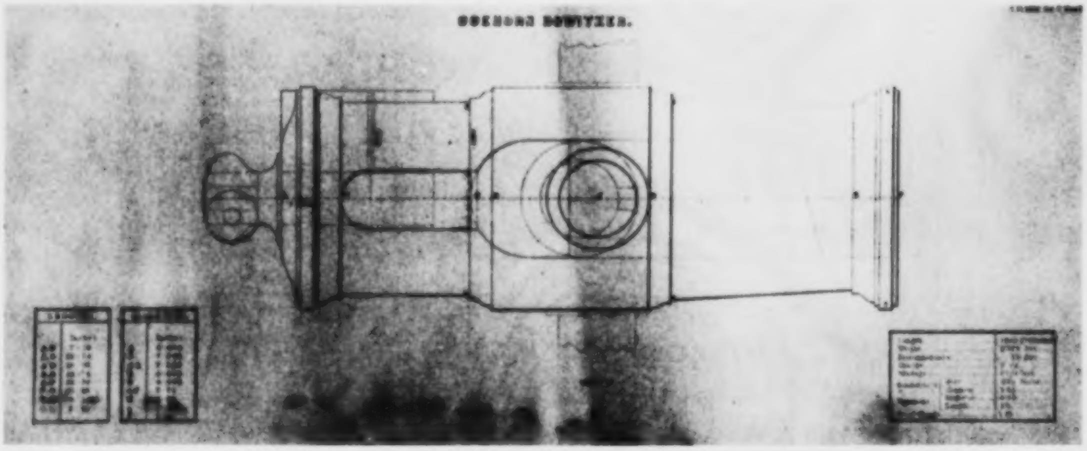

COEHORN HOWITZER.

Figure 101. Brass Coehorn Howitzer, weight: 2 hundredweight 1 quarter 14 pounds, length: 1 foot 10.6 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XXIX.)

Royal or 5-1/2-Inch Howitzer

It is not known precisely when the 5-1/2-inch brass howitzer, the howitzer equivalent to the Royal mortar, was introduced into the field service of the British army, but Glegg mentioned it in his notebook in the 1750s. While no dimensions were given its weight was said to be 4 hundredweight or slightly more.[13] According to Smith the Board of Ordnance established its dimensions in 1764 – calibre 5.62 inches, length 2 feet 2 inches, weight 4 hundredweight 14 pounds.[14] Although it was referred to in a number of practice books, no detailed specifications have been discovered until 1791. The length was usually stated to be 2 feet 2 inches but 2 feet 2-3/4 inches and 2 feet 2-1/2 inches were also given. The weight varied from 4 to almost 4-1/4 hundredweight.[15] It is impossible to know if these minor variations indicate changes or whether they merely reflect inaccuracies of casting or measurement. In any case it is unlikely that the changes would have been of great significance.

There is extant at the Rotunda, Woolwich, an example of a 5-1/2-inch brass howitzer of this period cast by the Verbruggens in 1782 (Fig. 102). It is one of a pair which King George III had presented to the Emperor of China in 1792 and which the British had recaptured near Peking in October 1860. Its length was not stated, but its weight has been cut into the cascable, 4 hundredweight 17 pounds.[16]

This weapon of 1782 appears to be very similar to the 5-1/2-inch howitzer drawn and detailed by Rudyerd in his notebook in 1791.[17] While it is impossible to compare the exact dimensions, the arrangement of parts and mouldings is identical. Rudyerd stated the length to be 2 feet 2.1 inches, a difference of 0.1 inch from the most commonly stated length. He did not give the weight. He also showed a slightly conical chamber:

length	6.01 inches
greatest diameter	3.2 inches
least diameter	2.45 inches.

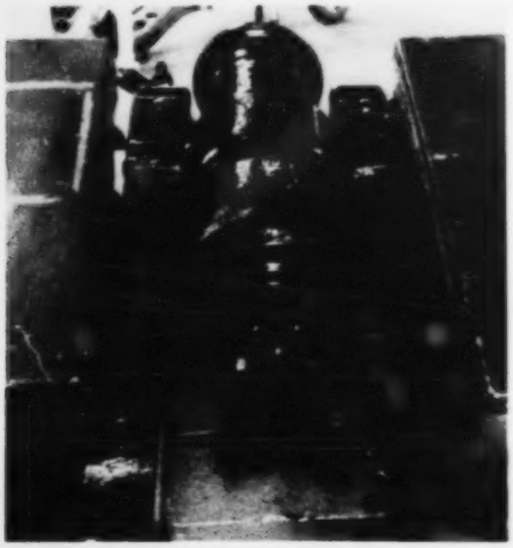


Figure 102. Brass 5-1/2-inch Howitzer, cast in 1782 by the Verbruggens, weight: 4 hundredweight 17 pounds. It has been painted black. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/68.)

It seems likely then that the 5-1/2-inch brass howitzer detailed by Rudyerd and exemplified at Woolwich was the standard pattern from 1764 (and perhaps before) until the 1790s.

This weight of howitzer, 4 to 4-1/2 hundredweight, continued to be mentioned in notebooks and manuals in the 1790s and early 1800s, when a slightly heavier version at 4-3/4 hundredweight, also made an appearance. It was recorded by Richard Bogue in his notebook composed between 1793 and 1802; he gave a weight of 4 hundredweight, 3 quarters, 14 pounds.[18] During the period May to August 1819 a 5-1/2-inch howitzer, length 2 feet 4 inches, weight 4 hundredweight, 3 quarters, 18 pounds, was involved in experiments firing spherical case shot. In 1825 Mould mentioned a similar howitzer of the same length, weighing 4-3/4 hundredweight.[19] Thereafter it was not mentioned. It had become obsolete and was replaced by Millar's 24-pounder brass howitzer (see below).

There is extant at the Royal Military Institution, Woolwich, two scaled drawings, made about 1820, of a 5-1/2-inch howitzer on a field carriage (Figs. 103 and 104). No weight was given; the length was about 2 feet 4 inches. Since its design was obviously based on the same principles of the Coehorn of the same period, it is reasonable to conclude that it too was designed in the 1790s.[20]

About this same time a heavy 5-1/2-inch brass howitzer also appeared. According to a note in the catalogue of the Rotunda Museum, Woolwich, "The first heavy 5-1/2-inch howitzers were cast about 1786 and another pattern in 1798, the last in 1819."[21] Hughes in his study says they were first cast about 1790.[22] The Rotunda, Woolwich, holds an example cast in 1813, length 2 feet 7.5 inches, weight 10 hundredweight (Fig. 105). The calibre is said to be 5.66 inches, somewhat larger than before.[23]

If the catalogue is correct, one might speculate that the pattern cast in 1786 was similar in appearance to the Rudyerd drawing of the light 5-1/2-inch howitzer, perhaps longer, of a greater diameter, and consequently heavier. The pattern of 1798, presumably that of the 1813 howitzer at Woolwich, was based on the same principles followed in the redesign of the Coehorn and the light 5-1/2-inch of that period. The major differences seem to have been the addition of dolphins and a dispart sight on the muzzle. Otherwise the arrangement of parts and mouldings was similar to the Coehorn at the Rotunda, cast in 1811. It is impossible to speculate what changes, if any, were made in the pattern of 1819. (The language of the catalogue is ambiguous and may mean no more than that no 5-1/2-inch howitzers were cast after 1819, and not that the last or latest pattern was cast in 1819.)

The heavy 5-1/2-inch howitzer was identified in Adye's manual of 1801 and again in the 1813 edition.[24] He gave a weight of 10 hundredweight but no dimensions. In 1811, two heavy 5-1/2-inch howitzers were used in a practice on Sutton heath, each 2 feet 8 inches in length and each weighing more than 9-1/2 hundredweight.[25] In 1819, a howitzer of the same length and weighing more than hundredweight was involved in experiments firing spherical case shot.[26] Thereafter the weight was said to be 10 hundredweight and the length 2 feet 8 inches or, very precisely, 2 feet 8.3 inches.[27] Only one manual, Griffiths' in 1847, noted the length at 2 feet 9 inches. The calibre was given sometimes at 5.62 inches, at other times at 5.66 inches. The weapon was chambered, but cylindrically not conically:

length	7.02 inches
greatest diameter	4.215 inches
least diameter	4.215 inches.[29]

According to Mould in 1825 the heavy 5-1/2-inch brass howitzer was intended for garrison use.[30] It was undoubtedly obsolete by the 1840s, not being included in Boxer's series of drawings nor being listed in the tables of artillery in the Aide-Mémoire.

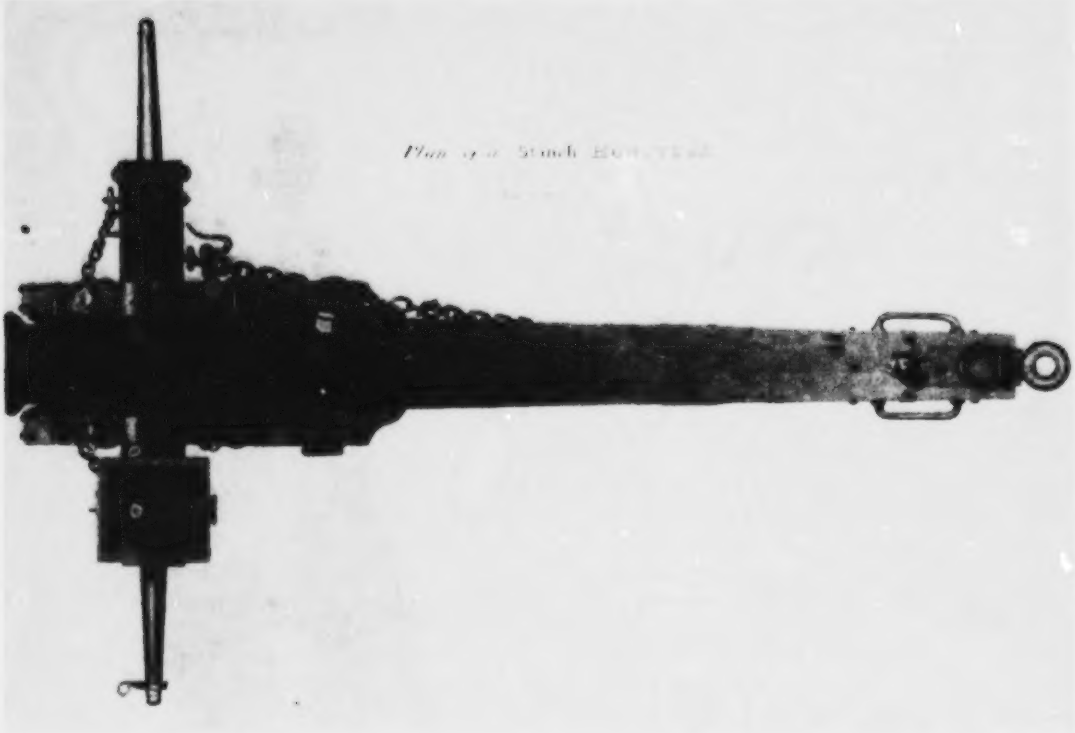


Figure 103. Brass 5-1/2-inch Howitzer on a block trail carriage, plan, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

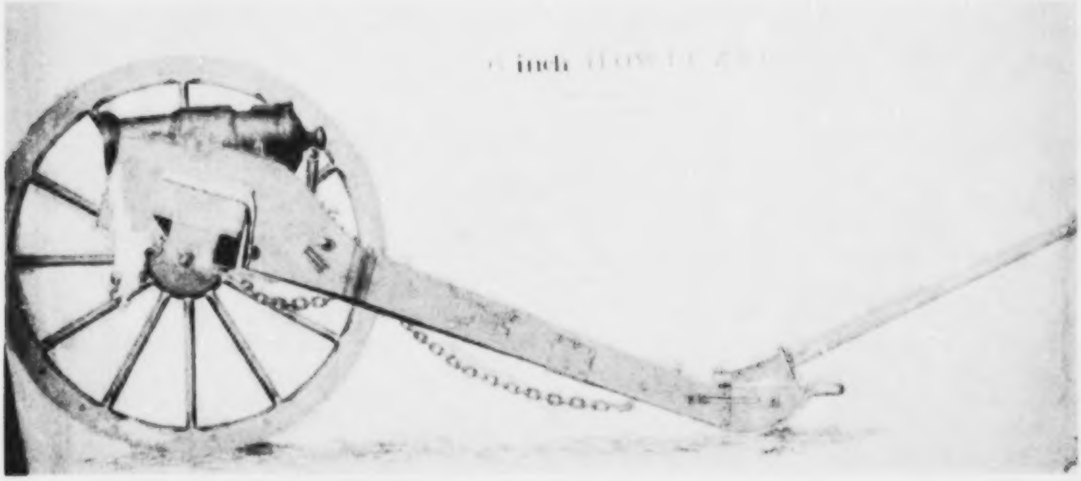


Figure 104. Brass 5-1/2-inch Howitzer on a block trail carriage, elevation, circa 1820. (The Royal Artillery Institution, Woolwich, U.K. Shuttleworth Drawings.)

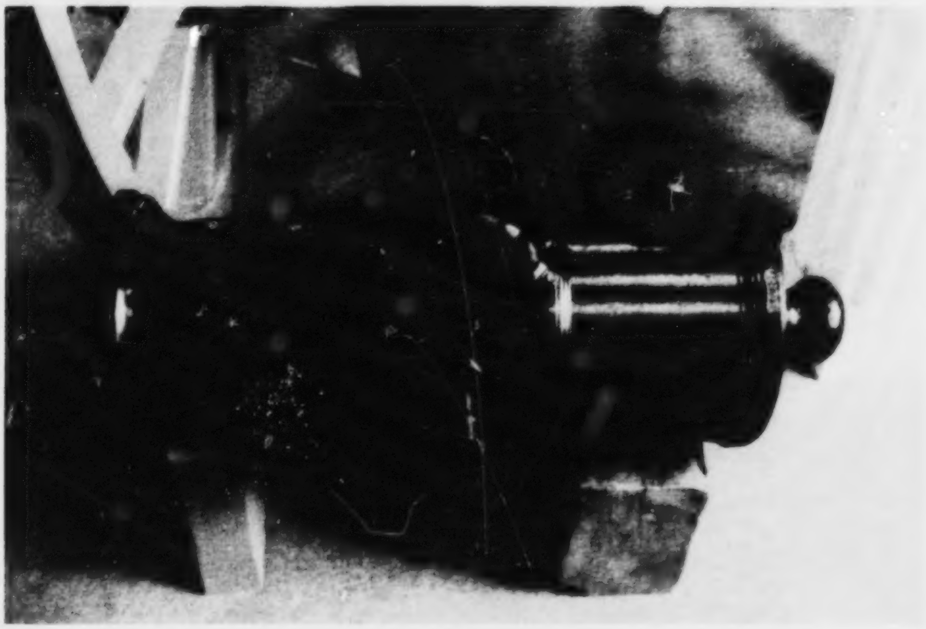


Figure 105. Brass 5-1/2-inch Howitzer (heavy), cast in 1813, weight: 10 hundredweight, length: 2 feet 7.5 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/78.)

8-Inch Howitzer

The history of the 8-inch brass howitzer is more confusing than that of the field pieces, paradoxically because there is more detailed information available about it and more examples extant. There is at the Rotunda, Woolwich, an early example from the reign of William and Mary, cast in 1695, 3 feet 7.5 inches long, weighing 15 hundredweight 2 quarters 22 pounds (Fig. 106).[31] It appears to match very closely a drawing of an 8-inch howitzer attributed to Albert Borgard, circa 1714 (Fig. 107).[32] About 10 years later, according to James in his notebook, the length of the 8-inch howitzer was 3 feet 1 inch.[33] It would seem that some change had been made in the design, perhaps as part of that standardization which Borgard had been commissioned to oversee in 1716. According to Hughes in his study of smooth-bore artillery and to the catalogue of the Rotunda Museum, Woolwich, the pattern of 3 feet 1 inch which superseded the older model was first cast in 1719.[34]

In Glegg's notebook which was compiled during the 1750s, there is a table entitled "Dimensions of Howitz^{rs}: in the Years 1727-1740. & 1744."[35] In it detailed lengths and diameters are given of a 10-inch howitzer and two 8-inch howitzers. One of the latter was 3 feet 4 inches long and weighed 15 hundredweight 2 quarters 9 pounds; the other was 3 feet 1.4 inches and weighed 12 hundredweight 1 quarter 11 pounds. The title appears to link 1727 and 1740 as a period of time and then 1744 as a separate date, but this is by no means clear; it could be stating three distinct dates on each of which one of the three sets of dimensions was established. All that can be said is that by 1744 there were two varieties of 8-inch howitzers in existence, the shorter of which may have been similar to that noted by James about 1725.

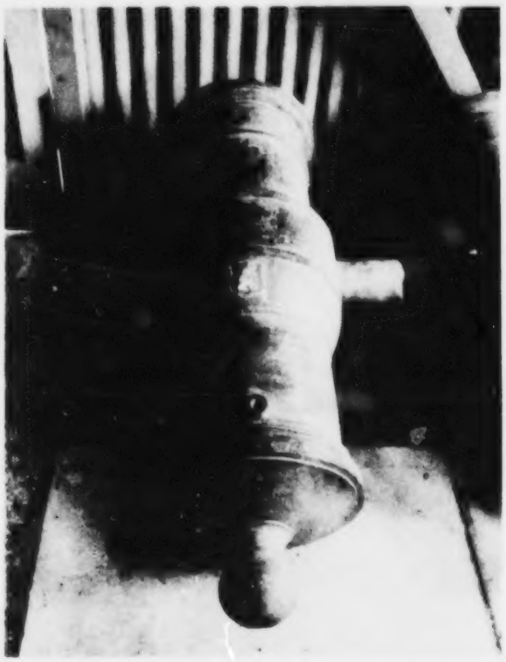


Figure 106. Brass 8-inch Howitzer, cast in 1695, weight: 15 hundredweight 2 quarters 22 pounds, length: 3 feet 7.5 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/26.

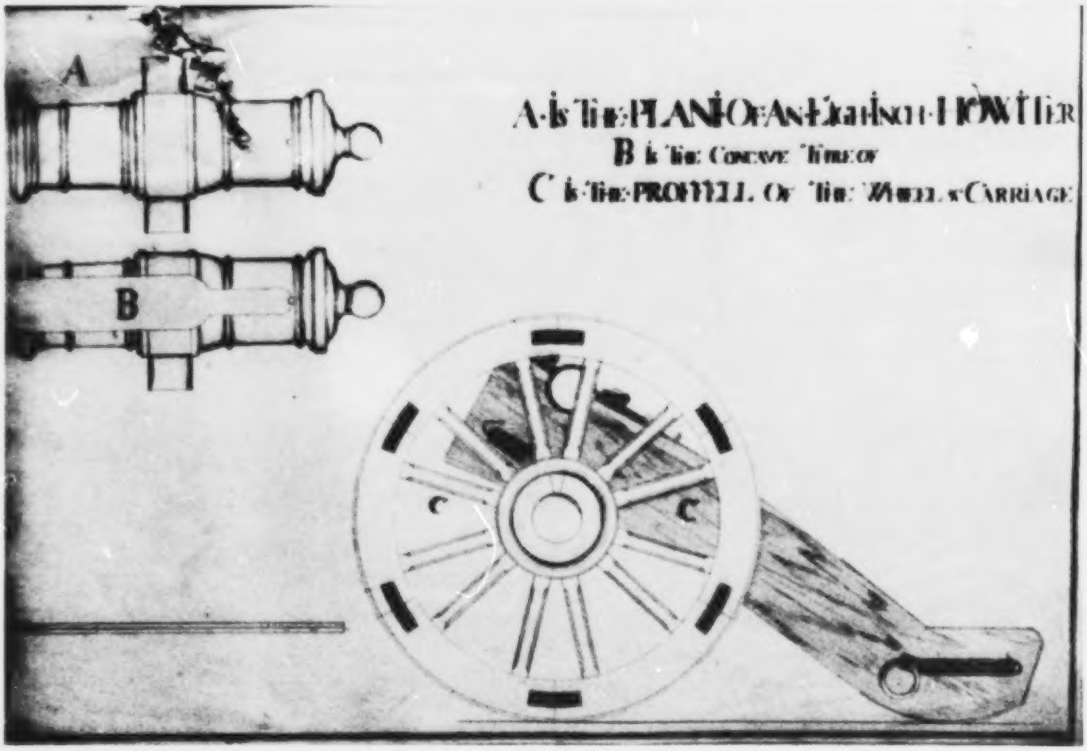

A
B
A·Is The PLAN Of An Eight Inch HOWITZER
B Is The Concave Thereof
C Is The PROFILL Of The Wheel & CARRIAGE
C
C

Figure 107. Brass 8-inch Howitzer and Carriage, circa 1714. (The Royal Artillery Institution, Woolwich, U.K., Borgard, "Practiss of Artillery.")

There is also extant a measured diagram of an 8-inch howitzer, which is part of a portfolio of drawings at the Royal Artillery Institution, Woolwich, tentatively dated circa 1735 (Fig. 108).[36] A comparison of the measurements on the diagram with those in Glegg's table reveals a very close similarity between those of the diagram and those of the 8-inch howitzer of 3 feet 4 inches and 15 hundredweight. No weight appears on the diagram but the length is only .25 inches longer and the diameters vary even less. It is not unreasonable to conclude that the drawing of the howitzer and the dimensions given by Glegg were of the same pattern.

The dimensions of the smaller howitzer in Glegg's table are very similar to dimensions given by Muller in his Treatise of Artillery, by Adye in his notebook, and by Smith in his dictionary.[37] The length was the same, as was the weight; there were minor variations in the size of the chamber, a difference of 0.1 inch in diameters, and the cascable, while the same length, may have been designed somewhat differently. Again it is reasonable to conclude that the howitzer in Glegg's table was the same howitzer (with perhaps a slightly different cascable) which was detailed by Muller, Adye, and Smith.

There is at the Rotunda a second 8-inch brass howitzer, this one cast by Gilpin in 1760 (Fig. 109). Surely this would be an example of one of the howitzers in Glegg's table. Unfortunately it does not match that shown in the circa 1735 diagram and, if its total length, 49.5 inches (i.e. from face of muzzle to end of button), is stated correctly, it is longer than either pattern detailed by Glegg. Its weight, 13 hundredweight 15 pounds, lies between theirs.[38] On the other hand, except that it is too long and heavy, it is very similar in appearance to the 8-inch howitzer drawn by Rudyerd in his notebook over 30 years later.

A comparison between the dimensions set out by Rudyerd in 1791 and those of the smaller 8-inch howitzer given by Glegg indicates a close similarity.[39] There are discrepancies both in lengths and in diameters but they are small. For example, Rudyerd gave a length of 37.2 inches, only 0.2 inch shorter than Glegg's weapon. Rudyerd's dimensions also seem to indicate that in 1791 the howitzer may have had

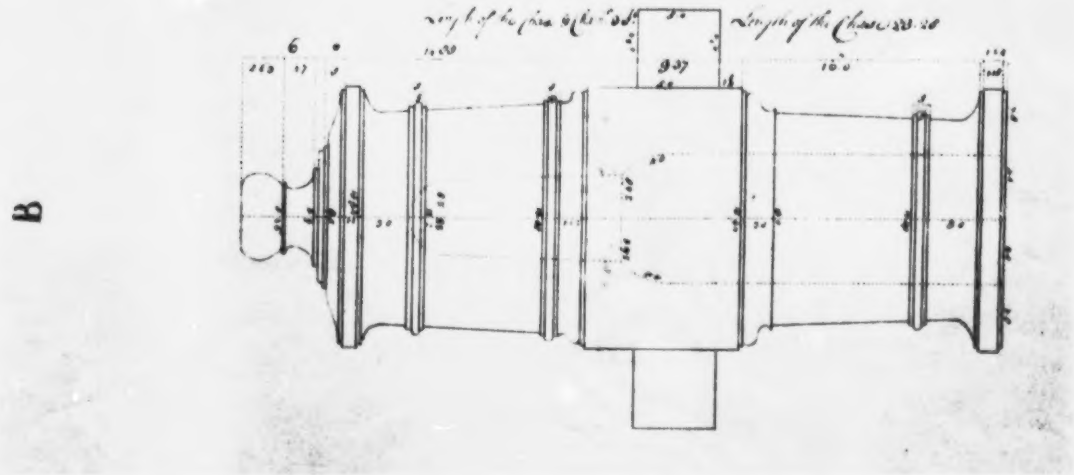


Figure 108. Brass 8-inch Howitzer. (The Royal Artillery Institution, Woolwich, U.K., A Portfolio of Drawings, circa 1735.)

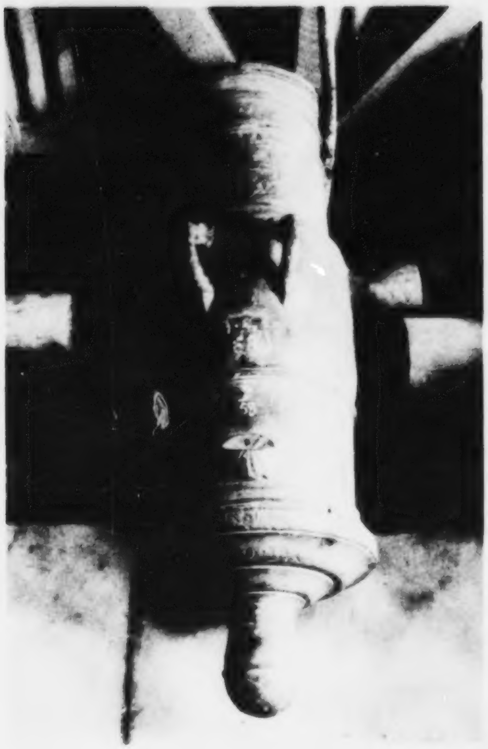


Figure 109. Brass 8-inch Howitzer, cast in 1760 by B. Gilpin, weight: 13 hundredweight 15 pounds, length: 49.5 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/58.)

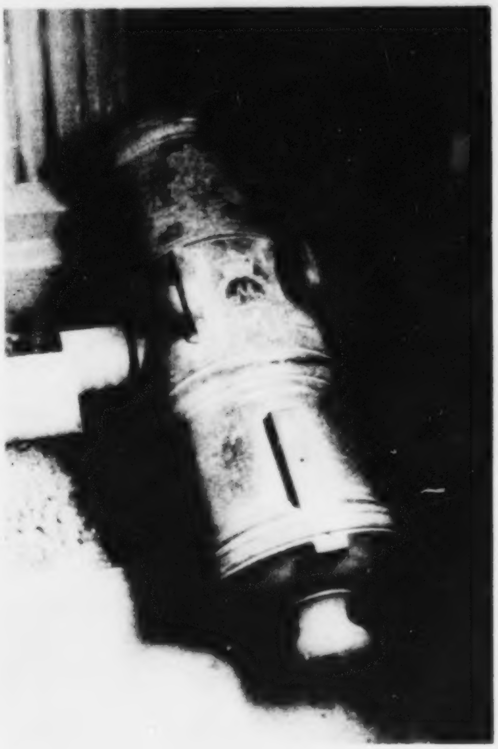


Figure 110. Brass 8-inch Howitzer, cast in 1814 by Henry and Charles King, length: 3 feet 4 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/81.)

slightly less thickness of metal around the bore. His mouldings also may have been slightly smaller. Perhaps the biggest change was to shorten the length of the slightly conical chamber by somewhat more than an inch. Essentially though the tables of dimensions indicate that the two patterns were very similar.

The differences may be accounted for, perhaps, by the regulations promulgated by the Board of Ordnance in 1764. According to Smith the 8-inch howitzer was to be 3 feet 1 inch long and to weigh 11 hundredweight.[40] Over the next 30 years or so there were references to 8-inch howitzers in various practice books; the length was variously quoted at 3 feet 1/2 inch, 1 inch, 1-1/2 inches, and even once at 3 feet 6 inches and the weight was given from 11 hundredweight to slightly more than 13 hundredweight.[41] It is impossible to know if these variations indicate changes in patterns or more likely the use of howitzers cast at different times. There would be no reason why a howitzer cast in 1740 could not be used alongside one cast in 1775, provided both were serviceable.

An example of the last pattern of this howitzer is also at the Rotunda, cast by the Kings in 1814 (Fig. 110). It is 3 feet 4 inches long but the weight is not given. There is also a drawing made by Shuttleworth in 1819 which is identical (Fig. 111).[42]

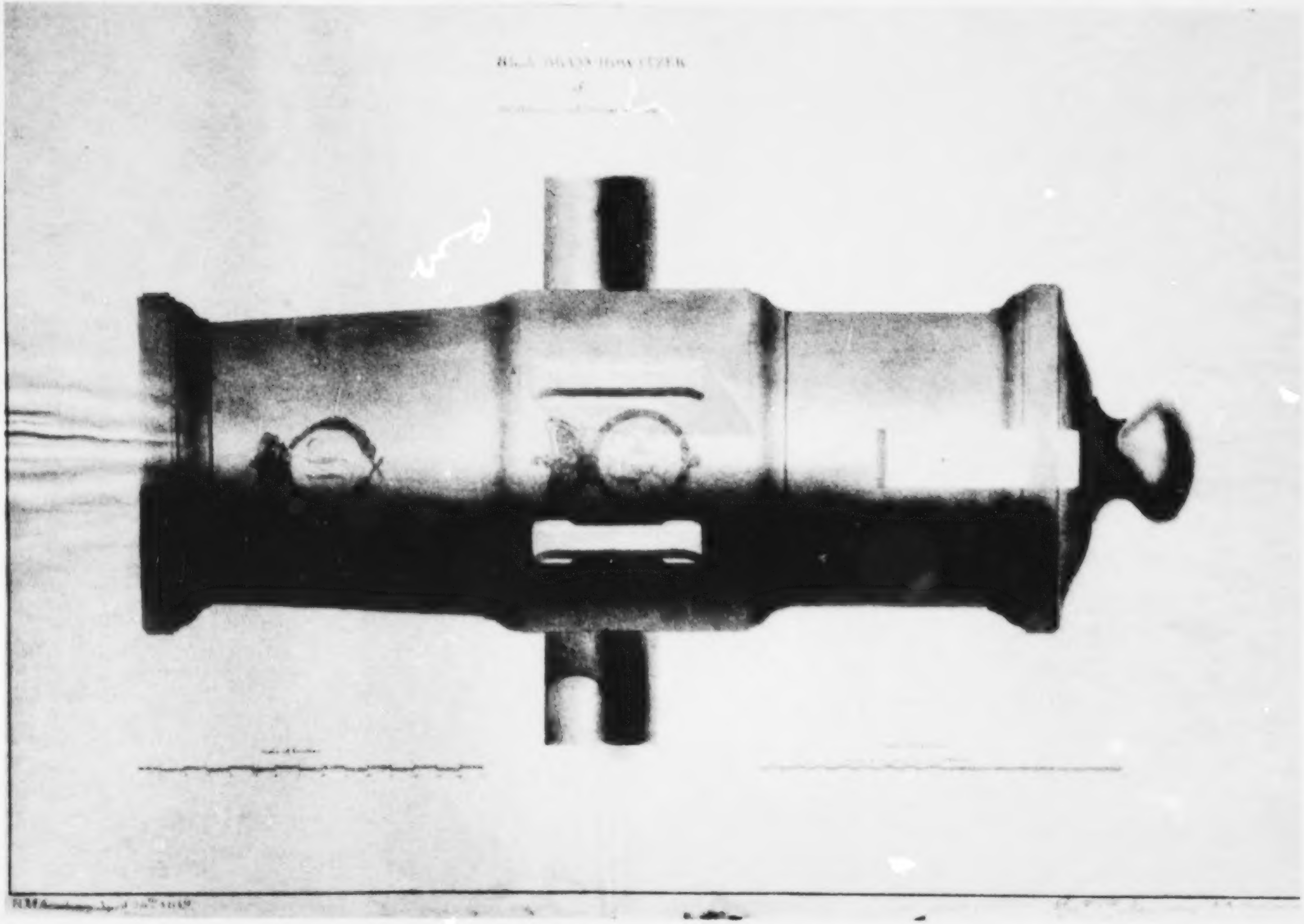

8 In. BRASS HOWITZER

Figure 111. Brass 8-inch Howitzer, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

This must be the same pattern 8-inch howitzer Mould referred to in 1825, noting that it was 3 feet 4 inches long and weighed 14 hundredweight.[43] The design was along the same lines as the Coehorn and 5-1/2 inch howitzers of the same period. The two reinforces were cylinders and the chase tapered slightly to the muzzle mouldings. The mouldings have been simplified, as has the cascable, the neck and button have been shortened, and a flat vent patch has been cast on the first reinforce. The dolphins were plain handles. It is reasonable to assume that this pattern of 8-inch howitzer came into service at the same time as the others, that is in the 1790s. The Aide-Mémoire claims that the weight of the weapon about 1790 was 14 hundredweight; unfortunately the source of this information is not cited.[44] The 8-inch howitzer was used in the Peninsular campaign, but following its failure there went out of service.[45] According to the catalogue of the Rotunda the last casting of it was in 1820.[46] No reference to it has been found subsequent to Mould's in 1825.

10-Inch Howitzer

There were three patterns of 10-inch brass howitzers. According to Hughes, the earliest casting was in 1727.[47] The table in Glegg's notebook entitled "Dimensions of Howitz^{rs} in the Years 1727-1740. & 1744" gives some support to this statement.[48] Certainly no references have been found to 10-inch howitzers before this date. In the table the details of the howitzer were set out. Its length was 4 feet 2.4 inches and it weighed 31 hundredweight 2 quarters 26 pounds. In appearance it resembled the 8-inch howitzer which appeared in the *circa* 1735 diagram. According to Muller, the "superfluous weight of the 10 inch howitz [sic] has occasioned its disuse, at least these 25 years."[49] When the 8-inch was redesigned about 1744, the 10-inch seems to have been ignored. There is no record, moreover, of its dimensions being established by the Board of Ordnance in 1764 as in the case of the 8-, 5-1/2-inch, and Coehorn howitzers.

A new pattern appeared in the 1770s. The older model was mentioned in a practice book for the period 1770-3, but thereafter the 10-inch howitzer reported was 3 feet 11 inches long (or slightly more) and weighed anywhere from 25-1/2 to slightly more than 25-3/4 hundredweight.[50] Partial dimensions were given in Walton's notebook, 1780-92, which agree very closely with those set down by Rudyerd in his notebook.[51] Rudyerd gave no weight, but the length was 3 feet 10.75 inches, slightly shorter than the length noted in the 1770s, although hardly a significant difference. It is a safe conclusion that the newly designed 10-inch howitzer which appeared in the 1770s was that which Rudyerd drew in 1791.

A comparison of the dimensions of this pattern with those of the earlier version given by Glegg, indicates that, other than the decrease in length, the most marked change was in the chamber size. The dimensions of the chamber of the earlier howitzer were:

length	16.8 inches
greatest diameter	6.5 inches
least diameter	5.6 inches.

The chamber dimensions given by Rudyerd were shorter and narrower:

length	12.6 inches
greatest diameter	5.775 inches
least diameter	4.12 inches

This howitzer had much the same history as the 8-inch; it was used in the Peninsular campaign and failed due to age and wear (see above).[52] It was replaced by a third pattern. There is a record of a 10-inch howitzer 4 feet 2 inches long and weighing slightly more than 27-3/4 hundredweight being used at a practice on Sutton

Heath in 1811.[53] There is at the Rotunda Museum, Woolwich, a 10-inch brass howitzer, cast by the Kings in 1814, 4 feet 2 inches long (Fig. 112). No weight was marked on it. It is the same pattern as the 8-inch cast by the Kings that same year (see above). According to the Museum catalogue the 10-inch was last cast in 1816.[54] No references to it have been found beyond Mould's note in 1825 when he recorded its length at 4 feet 2 inches and its weight at 27 hundredweight.[55]

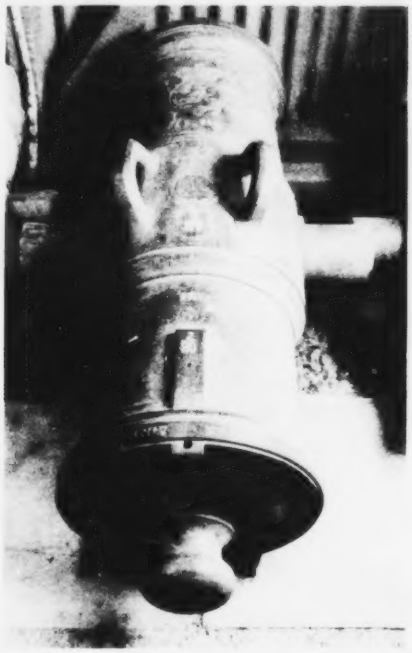


Figure 112. Brass 10-inch Howitzer, cast in 1814 by Henry and Charles King, length: 4 feet 2 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/80.)

Millar's Howitzers

Following the Napoleonic wars William Millar designed two new brass howitzers, a 12-pounder and a 24-pounder, to replace the 4-2/5-inch Coehorn and the 5-1/2-inch Royal howitzers in the field and horse artillery batteries (Fig. 113). They were much longer than the older weapons, being 10 calibres in length. In profile they were similar to guns, being smaller brass versions of the iron shell-guns that Millar also introduced into the service about the same time. In structure they were composed of three truncated cones, that is two reinforces and chase. The muzzle swell no longer equalled the base ring in diameter but was surmounted by a dispart sight to compensate for the difference. The cascable design was simplified and a loop cast underneath the button for attaching the elevating screw. The parts were separated by four plain rings and the vent field was set off by an astragal and fillets. The older, slightly conical chamber was replaced by one of the Gomer design. These howitzers were brought into service in the early 1820s. Later, about 1840, a 32-pounder of the same design was introduced by Colonel Dundas.

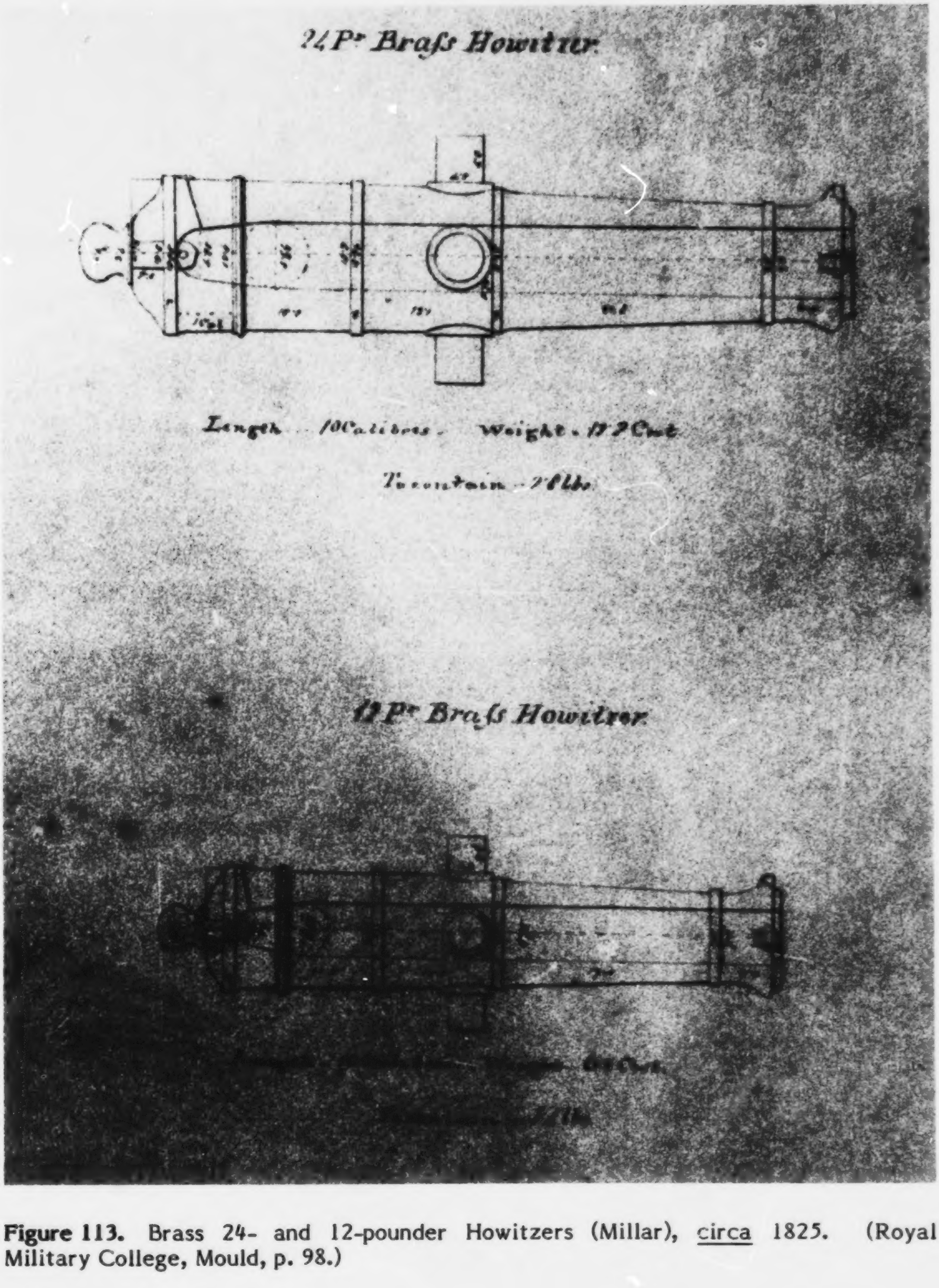

24 Pr Braſs Howitzer
Length . . 10 Calibres . Weight . 12 2 Cwt
To contain . 28 lbs
12 Pr Braſs Howitzer

Figure 113. Brass 24- and 12-pounder Howitzers (Millar), circa 1825. (Royal Military College, Mould, p. 98.)

12-Pounder

The 12-pounder brass howitzer was introduced into the service in 1820 or 1822 although there are records of it being used in experiments and practice in 1819.[56] It was to be used in batteries with the 6-pounder brass gun, replacing the 4-2/5-inch Coehorn howitzer.[57] Its length was 45.2 inches (that is, 10 calibres) throughout its career and its weight was usually stated at 6-1/2 hundredweight, although there are examples extant weighing slightly less at a little more than 6 hundredweight.[58] Initially its calibre was 4.52 inches, the same as the Coehorn which it was replacing, but, probably in the 1830s, it was increased to 4.58 inches.[59] The bore of the 12-pounder terminated in a Gomer chamber, 6.8 inches long tapering to a hemisphere of 3.4 inches in diameter.[60] The cascable had been simplified in design and a loop had been cast under the button to take the elevating screw. (The earliest design seems not to have had the loop. See Fig. 113.) There was a vent patch on the first reinforce, a dispart sight on the muzzle; four plain rings and a vent astragal and fillets separated its parts. It was last cast in 1859, being replaced by the Armstrong gun in the 1860s.[61] At the Rotunda there is an example extant, cast in 1853, which precisely illustrates the design (Fig. 115).[62]

There were also two 12-pounder howitzers designed for sea service. One was identical to the land service pattern, except that it was cast with a breeching loop and the second reinforce ring had been turned off. It could be used on boat service or landed on a field carriage; two were put on board first to sixth rates and one on board brigs and smaller vessels.[63] There is a sea service howitzer of this pattern, cast in 1858, at the Rotunda, Woolwich (Fig. 116). It was manufactured without the loop for attaching the elevating screw.[64]

A heavier 12-pounder was designed by Colonel Dundas and introduced into the service probably in the early 1840s. It was 4 feet 7 inches long and weighed 10 hundredweight. Its use was restricted to fourth and fifth rates.[65] Other than these facts, little else is known about this howitzer.[66]

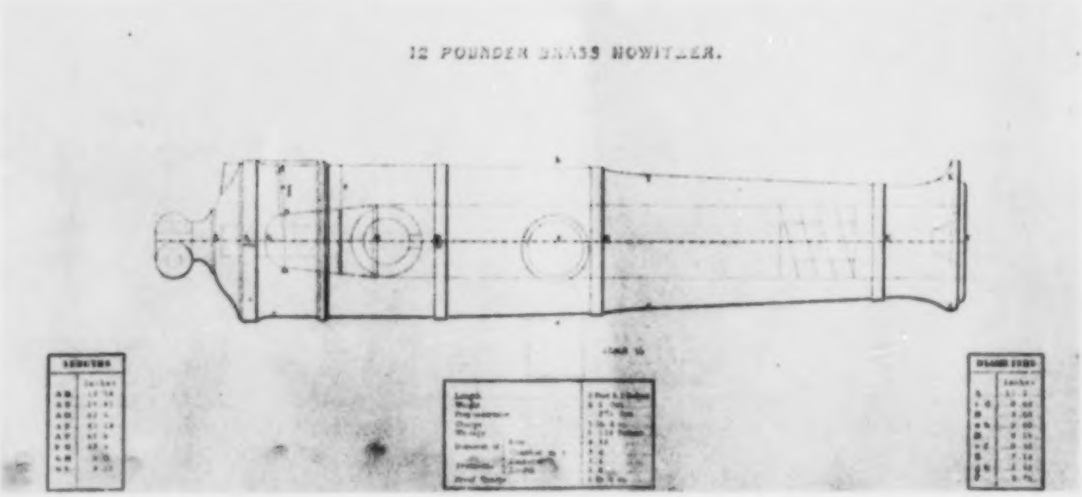
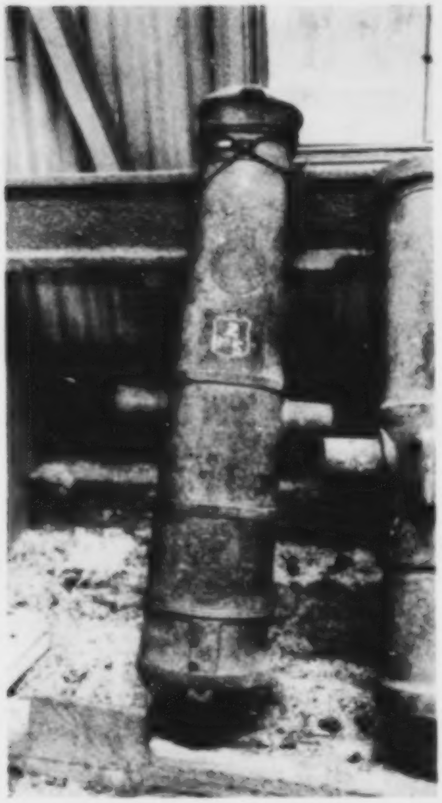


Figure 114. Brass 12-pounder Howitzer (Millar), weight: 6.5 hundredweight, length: 3 feet 9.2 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XXVIII.)

Figure 115. Brass 12-pounder Howitzer (Millar), cast in 1853 by S. Eccles, weight: 6 hundredweight 2 quarters, length: 3 feet 9 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/85.)



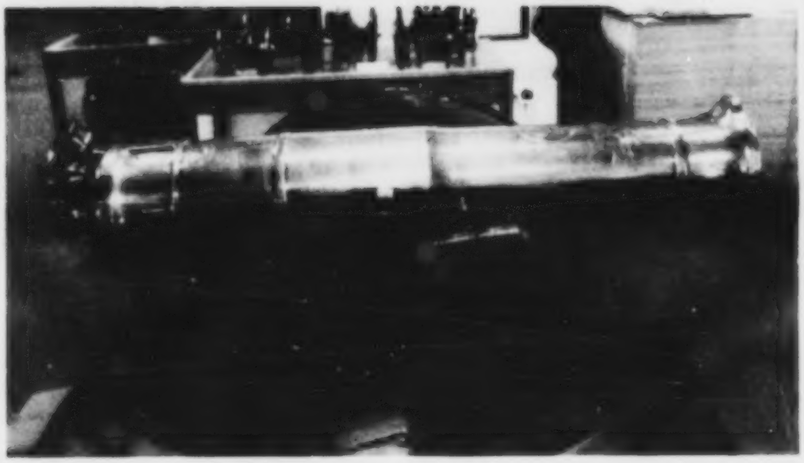


Figure 116. Brass 12-pounder Sea Service Howitzer (Millar), cast in 1858 by F.M. Eardley-Wilmot, weight: 6 hundredweight 26 pounds, total length: 50.25 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, II/71.)

24-Pounder

The history of the 24-pounder is very similar to that of the 12 pounder. Designed by Millar on the same principles as the lighter weapon, it too was being used in experiments and practice in 1819 and was introduced into the service in 1820 or 1822.[67] It was to be used in batteries with the 9-pounder brass gun, replacing the 5-1/2-inch Royal howitzer.[68] Its length was usually stated at 56.6 inches (that is, 10 calibres) and its weight at from 12 to 13 hundredweight.[69] Initially its calibre was 5.66 inches but, probably sometime in the 1830s, this was increased to 5.72 inches.[70] Like the 12-pounder, its bore terminated in a Gomer chamber, which was originally 8.5 inches long tapering to a hemisphere 4.25 inches in diameter.[71] By 1850 the size of the chamber had been adjusted. In his diagram Boxer indicated that its length was 7.85 inches tapering to 4.15 inches; the Aide-Mémoire in 1853 gave slightly different dimensions, 7.86 inches in length tapering to 4.2 inches.[72] The cascable design was the same as the 12-pounder and the howitzer had the same four rings, astragal and fillets, vent patch, and dispart sight (Fig. 117). The 24-pounder brass howitzer continued in general service until 1861.[73]

The 24-pounder was also designed for sea service (Fig. 118). Like the sea service 12-pounder, it duplicated the land service pattern except for the addition of a breeching loop, the loss of the second reinforce ring, and the vent field astragal and fillets, and a minor change in cascable design.[74] There is a pair of these cast in 1859, in the grounds of the National Maritime Museum, Greenwich, on which these characteristics can be clearly seen. Two of these were carried on board first, second, and third rates, which could be used in their boats or mounted on field carriages for use with landing parties. They were also used on gunboats during the Crimean war.[75]

There was also mention of a 24-pounder 4 feet long weighing 10 hundredweight which, according to Hughes, was cast for the Indian service.[76]

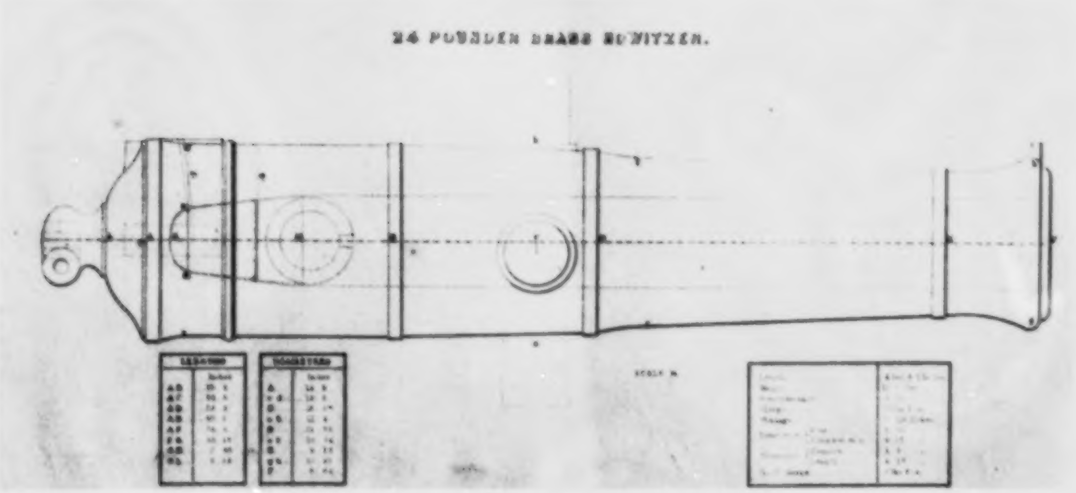


Figure 117. Brass 24-pounder Howitzer (Millar), weight: 12.5 hundredweight, length: 4 feet 8 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XXVII.)

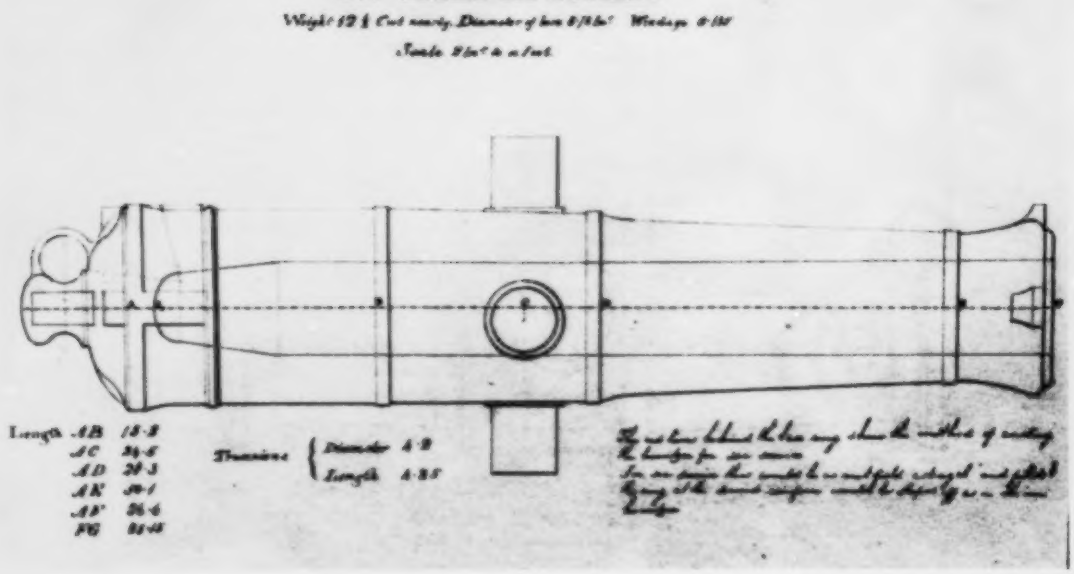


Figure 118. Brass 24-pounder Sea Service Howitzer (Millar), weight: 12.5 hundredweight, length: 56.6 inches, circa 1850. (The Royal Artillery Institution, Woolwich, U.K., Strange, "Drawings on Artillery.")

32-Pounder

The 32-pounder howitzer was designed by Colonel Dundas on the same principle as the two Millar howitzers (Fig. 119). It was introduced into the service in 1840 or 1841.[77] Originally intended to accompany 12-pounder guns, it was used by itself as a gun of position in batteries of four during the Crimean war.[78] None was cast after 1854.[79]

It was 63 inches long and weighed 17 1/- to 18 hundredweight. Its calibre was 6.3 inches and its bore terminated in a Gomer chamber, 10.25 inches long tapering to a hemisphere 5 inches in diameter. Like the Millar howitzer it was cast with four rings, vent astragal and fillets, a vent patch, and a dispart sight mounted on the muzzle. It did not have a loop to take an elevating screw.[80] An example of a 32-pounder, cast in 1854, is in the Rotunda Museum at Woolwich.[81]

Iron Howitzers

5-1/2-Inch or 24-Pounder Howitzer

The history of this howitzer is rather obscure. According to Miller, writing in 1864, it was first cast in 1800.[82] A notebook contains a reference to a practice with

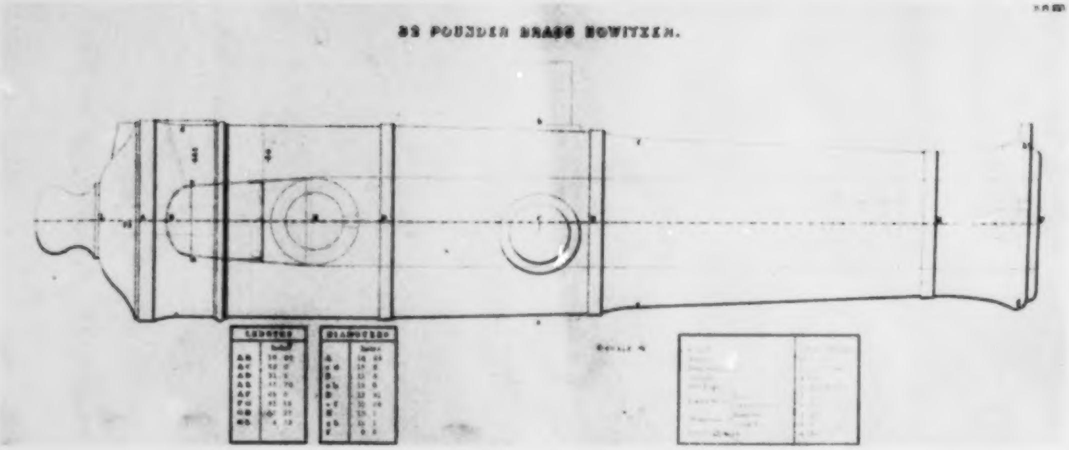


Figure 119. Brass 32-pounder Howitzer (Dundas), weight: 17.5 hundredweight, length: 5 feet 3 inches, circa 1850. (Boxer, Diagrams of Guns, Plate XXVI.)

an iron 24-pounder howitzer of 16 hundredweight 4 pounds on Sutton Heath in November 1810. According to the brief note.

> The Howr was on its standing & traversing Carriages similarly placed to their Position on the Martello Tower for which the Howr was designed.[83]

Unfortunately no other details were given.

There is at the Rotunda, Woolwich, a rather strange looking piece, described as a 24-pounder iron howitzer "originally intended for Martello towers" (Fig. 120). Its length is 2 feet 9 inches, its weight 11 hundredweight 3 quarters 4 pounds.[84] It is constructed with one reinforce separated from the chase by a ring. There are also rings at the base and muzzle and a dispart sight on the latter. The cascable resembles that of a carronade except that it ends in a diamond shaped lug to which two curved handles were attached, one of which has been broken off. No date of casting has been ascribed to this piece. It is impossible to know whether or not this is a lighter version of the howitzer that was employed on Sutton Heath in 1810.

As previously stated, Miller claimed in 1864 that "... the existing pattern was first cast in 1800..." and was "...of older date than those constructed by General Millar [i.e. the 8- and 10-inch iron howitzers], and has consequently a cylindrical instead of a gomer chamber." He went on to describe it:

> ...it has a dispart at the muzzle, a vent patch, and a block behind the base ring; the cascable has a plain button; there are no rings except at the base and muzzle, and the vent is perpendicular.

He gave the length at 3 feet 5 inches and the weight at 15 hundredweight.[85] Except for the perpendicularity of the vent this description matches well with Boxer's drawing, published in 1853, of an iron 24-pounder howitzer (Fig. 121).[86] It also would describe, except for the lack of a dispart sight, the howitzer depicted in a scaled drawing by Shuttleworth in 1819 (Fig. 122).[87]

The records, such as they are, for the 1820s, are not very satisfactory. Mould in 1825 and Adye in 1827 recorded two iron 5-1/2-inch howitzers. Mould gave lengths

Figure 120. Iron 24-pounder Howitzer, said to be originally intended for Martello towers, weight: 11 hundredweight 3 quarters 4 pounds, length: 2 feet 9 inches. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, III/41.)

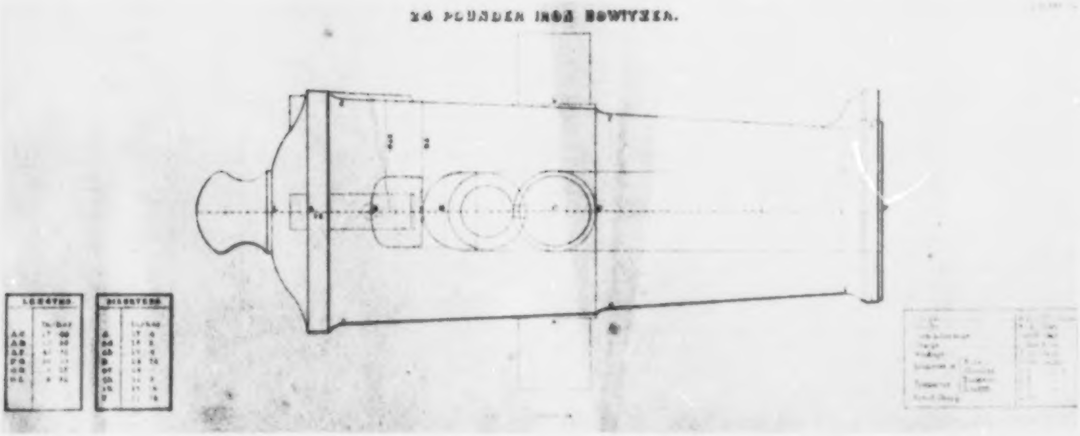

24 POUNDER IRON HOWITZER.
LENGTHS
DIAMETERS

Figure 121. Iron 24-pounder Howitzer, weight: 15.5 hundredweight, length: 40.76 inches, *circa* 1850. (Boxer, *Diagrams of Guns*, Plate XXV.)

of 3 feet 6 inches and 3 feet 10 inches and weights of 15 and 12 hundredweight respectively. Adye gave only weights, 15 and 13 hundredweight.[88] It seems strange that in Mould's table the longer howitzer was the lighter. This particular length of howitzer was recorded by Griffiths in his manuals from 1839 to 1852 but he gave a weight of 15 or 15-3/4 hundredweight.[89] It seems impossible to conclude much more than that two patterns of iron 5-1/2-inch howitzers were in existence early in the century.

In 1825 Mould commented on the iron 5-1/2-inch howitzer — "Not used, but are good Garrison Howitzers."[90] Except for Adye in 1827 and Griffiths in the 1840s and '50s, the authors of manuals ignored this weapon, which neglect suggests that Mould's remark remained true. In the late 1840s it was recorded by a student at the Royal Military Academy and by Sir Howard Douglas in his study of naval gunnery.[91] Detailed specifications were set out in the Aide Mémoire in 1845, and Boxer published both measurements and a diagram in 1853.[92] The specifications given by Boxer agree in most respects with those of the Aide-Mémoire, except most notably in the diameter of the chamber. Both chambers were cylindrical, but Boxer's was much larger. The Aide-Mémoire indicated a length of 5.1 inches and a diameter of 3.64 inches while Boxer showed a length of 5.25 inches and a diameter of 5.1 inches.[93]

In 1864 Miller wrote:

> The 5-1/2-inch howitzer is almost obsolete, but a few may still be found in the flanks of old fortified places. Pieces of this class and calibre were also included in armaments on

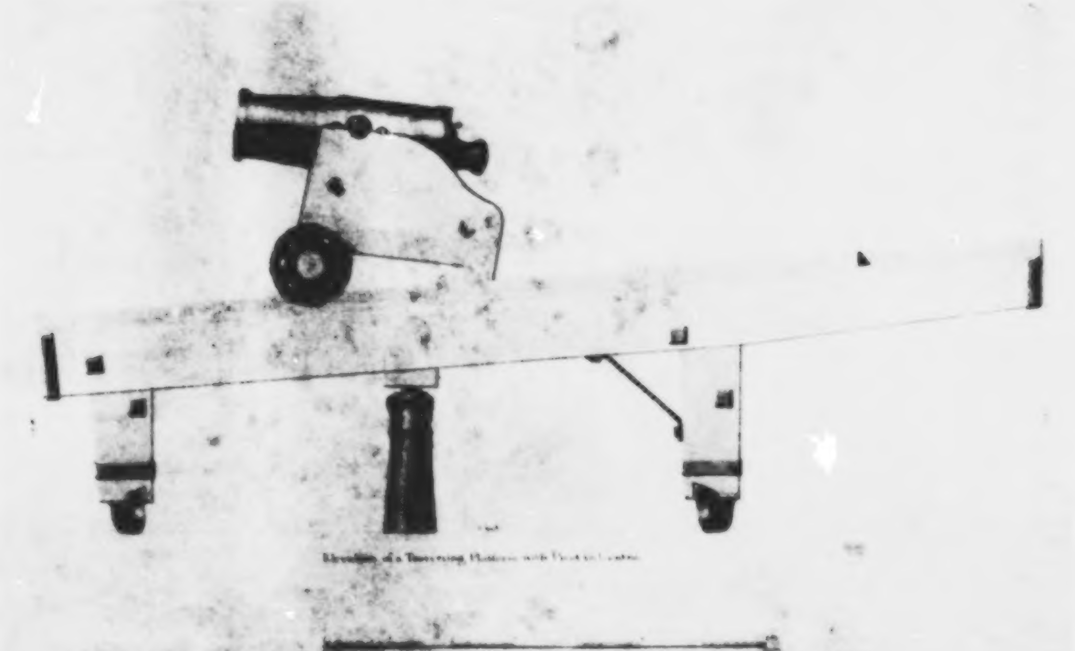


Figure 122. Iron 24-pounder (?) Howitzer on Traversing Platform, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

> account of their being so easily moved to any threatened point.[94]

On 1 January 1866 the piece was officially declared obsolete, although it was to be retained, if already mounted on works, until its carriage wore out at which time it was to be replaced.[95]

8-Inch and 10-Inch Howitzers

The histories of these howitzers are so similar that they can be recounted at the same time. Both weapons were designed on the same principles by Wiliam Millar in 1819 or previously, for in that year they were used in experiments at Woolwich.[96] The next year a committee of artillery officers suggested that they be adopted for the battering train, a recommendation made "on a supposition of the new Iron 10 Inch and 8 Inch Howitzers being introduced into the service..." to replace those of brass.[97] Hughes, in his study of British smooth-bore artillery, says they were introduced "by 1820," but Miller, writing in 1864, claimed they were not brought in until 1825.[98] In that year Mould, a student at the Royal Military Academy, noted that they were to be used in battering trains and in garrison.[99]

Although there were minor changes in dimensions, the basic appearance of these howitzers did not change over the years. Each was 6 calibres long, that is 4 feet and 5 feet respectively. The length of the two reinforces equalled that of the chase. The parts of the howitzer were set off by plain rings at the base, between the two reinforces, and at the muzzle; the second reinforce was distinguished from the chase by a short curve rather than a ring. The cascable was simply designed, terminated by a plain button. There was a dispart sight on the muzzle swell and a block behind the base ring. The vent was drilled at an angle through the base ring into the Gomer chamber which terminated the bore.[100]

While this basic design did not change, there were minor changes in dimensions. A comparison of three sets of dimensions — those given in Mould's diagram of 1825 (Fig. 123), those of the Aide-Mémoire of 1845 and 1853, and those of Boxer in 1853 (Figs. 124 and 125) — indicate that there was an increase in the diameters of tne parts of the howitzer.[101] These changes were reflected by an increase in weight of the howitzers from about 1-1/2 to 2-1/2 hundredweight respectively. These modifications probably occurred in the 1830s; the 8- and 10-inch howitzers used in the major practice at Deal in 1839 were considerably heavier than those used 20 years before.[102]

There were also changes to the length of the bore and perhaps to the diameter of the chamber. The bores of both howitzers were shortened from about 1 inch to 1-1/4 inches respectively, probably at the same time as the exterior diameters were altered. As to the size of the chamber, the major sources do not agree. The length remained constant in both howitzers but the least diameter of the chamber may have been changed slightly.[103]

Both howitzers remained in service throughout the period and, in 1865, following a review of all ordnance, it was recommended that both continue in service.[104] As late as 1881 they were still listed, but undoubtedly they were of minor importance.[105]

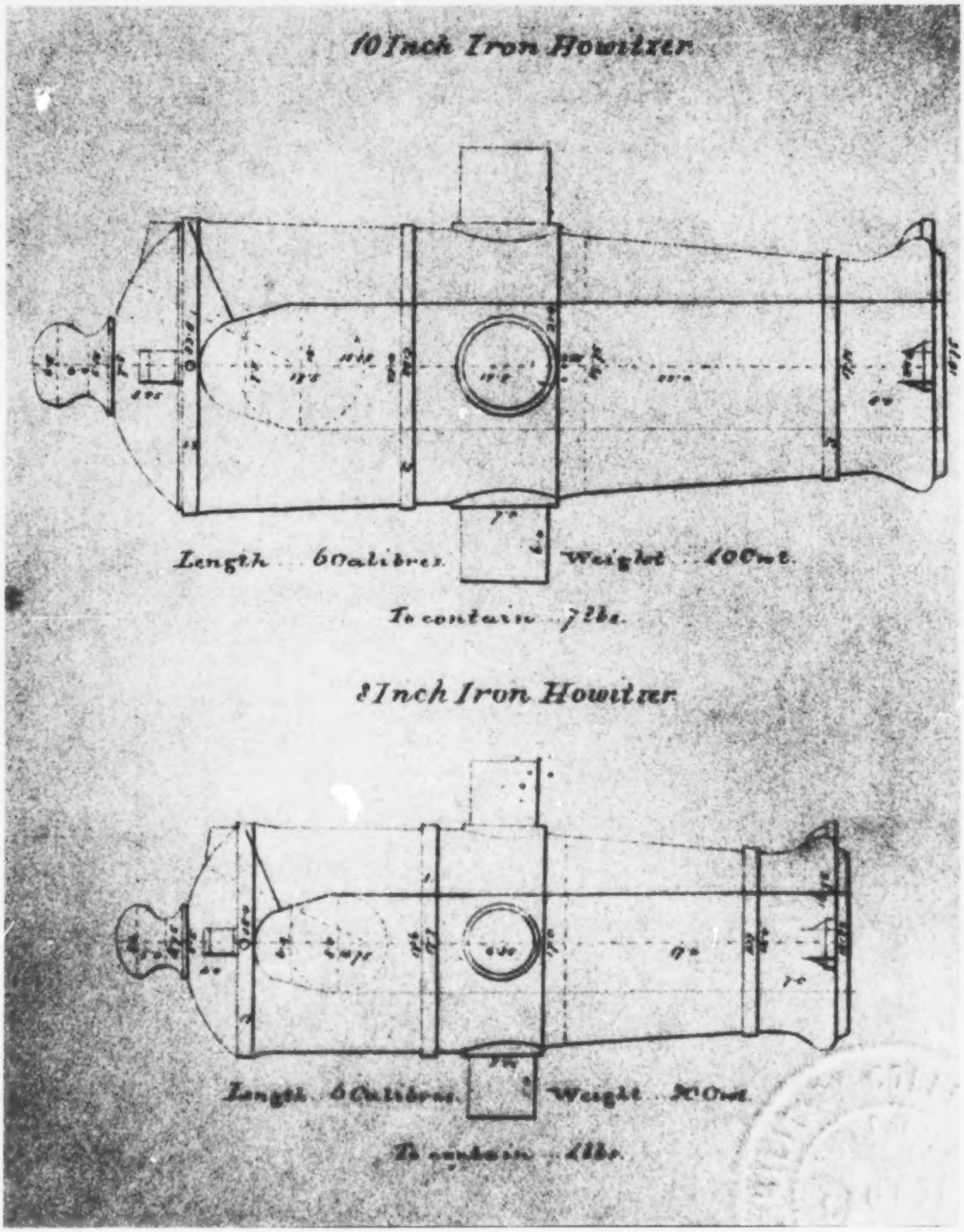

10 Inch Iron Howitzer
Length ... 6 Calibres. Weight ... 40 Cwt.
To contain ... 7 lbs.
8 Inch Iron Howitzer
Length ... 6 Calibres. Weight ... 20 Cwt.
To contain ... 4 lbs.

Figure 123. Iron 10-and 8-inch Howitzers, circa 1825. (Royal Military College, Mould, p. 99.)

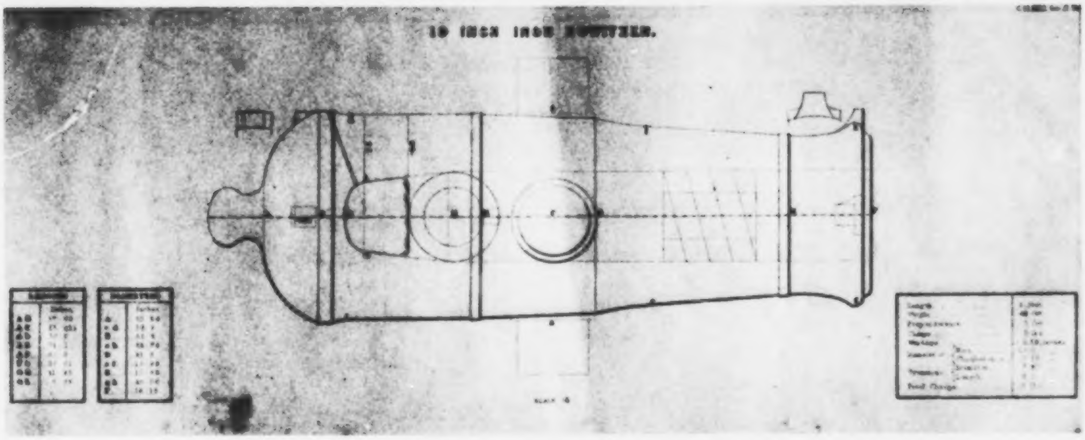

10 INCH IRON HOWITZER.

Figure 124. Iron 10-inch Howitzer, weight: 42 hundredweight, length: 5 feet, circa 1850. (Boxer, Diagrams of Guns, Plate XXII.)

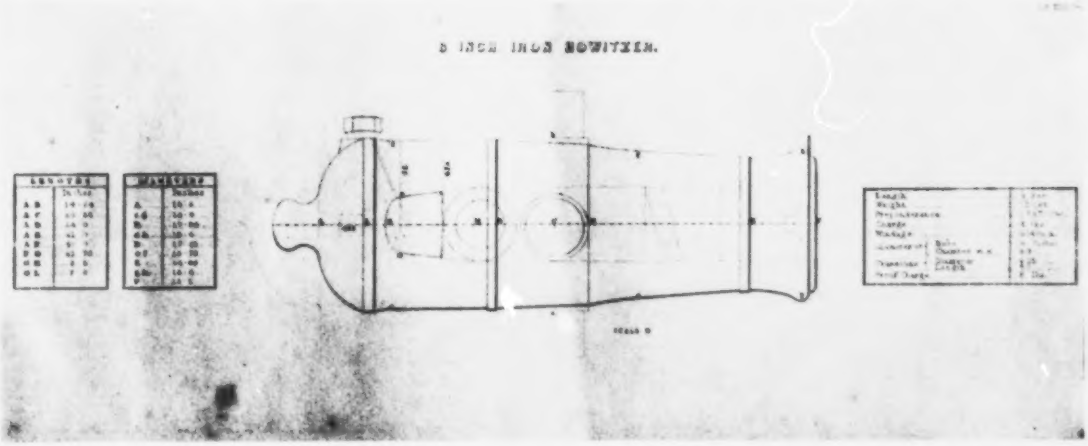

8 INCH IRON HOWITZER.

Figure 125. Iron 8-inch Howitzer, weight: 22 hundredweight, length: 4 feet, circa 1850. (Boxer, Diagrams of Guns, Plate XXIII.)

Figure 126. Iron 8-inch Howitzer, cast in 1859, weight: 22 hundredweight 10 pounds, length: 4 feet. (National Battlefields Commission, Plains of Abraham, Québec.)

CARRIAGES AND LIMBERS

Gun carriages may be divided into two categories – garrison carriages and travelling carriages. For much of its history the common standing garrison carriage remained relatively unchanged, a simple wooden machine consisting of two brackets, a transom, two axletrees, four cast iron trunks, and a stool bed (Fig. 127). Late in its history variations of this design appeared in response to special circumstances. The rear chock carriage, in which the rear axletree and trucks were replaced by a chock or block of wood, was an attempt to control the violent recoils of certain pieces. The sliding carriage, in which both axletrees were replaced by wooden blocks, was placed on a traversing platform. The notable exception to this general description of the garrison carriage was the mortar bed, which was a solid block of wood shaped to receive the mortar and resting directly on the platform. These carriages were not designed to be moved from place to place but to remain in one position in a fort, tower, or permanent battery. If it was necessary to move them, specially designed carriages were used.

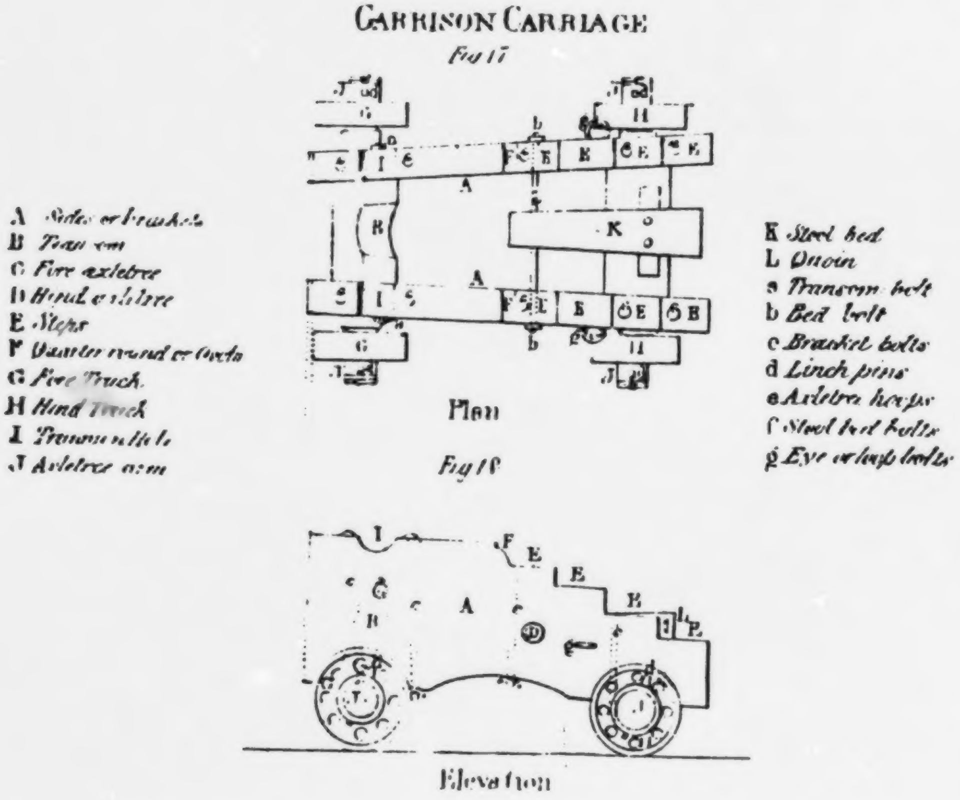
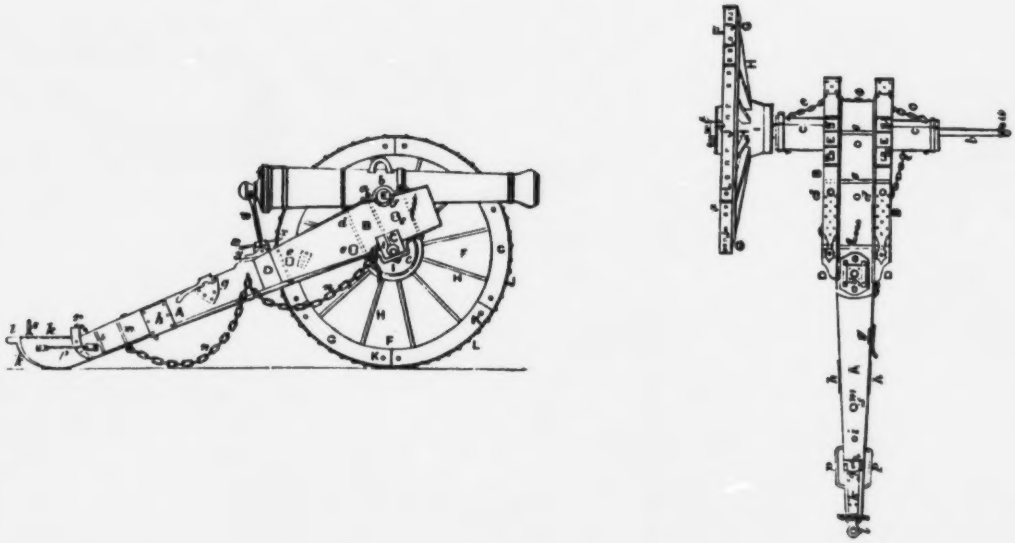

Garrison Carriage
Fig 17
A Sides or brackets
B Transom
C Fore axletree
D Hind axletree
E Steps
F Quarter round or Ovolo
G Fore Truck.
H Hind Truck
I Trunnion holes
J Axletree arm
K Stool bed
L Quoin
a Transom bolt
b Bed bolt
c Bracket bolts
d Linch pins
e Axletree hoops
f Stool bed bolts
g Eye or loop bolts
Plan
Fig 18
Elevation

Figure 127. Common Standing Garrison Carriage. (Straith, Plates (1852.)

Travelling carriages, as the name clearly implies, were designed to be moved to bring up the guns either to support the infantry and cavalry during battle or to batter fortresses or city walls during a siege. They were categorized by function – field, position, and siege, but the latter two distinctions in terms of design were artificial. A more meaningful distinction was light and heavy. A travelling carriage consisted of an axletree, two wheels, and a body or trail, the ends of which rested on the ground. Initially the body was composed of two brackets joined by transoms, but for field carriages in the 1790s, these were replaced by a solid block of wood to which two small brackets were bolted to support the trunnions of the piece (Fig. 128). The heavier position and siege carriages retained the double bracket trail until about 1860. Iron axletrees were adopted at the same time as the block trail, and the wheels and axletrees were standardized.

When it was necessary to move travelling carriages, they were attached to two wheel vehicles called limbers. In essence a limber was two wheels on an axletree, with a pintle – either straight or crooked – to which the trail of the carriage was hooked. By joining a carriage to a limber a four-wheel vehicle was created which provided better traction and greater stability, especially in moving over bad roads or rough ground. Although this basic design remained the same, the limber also underwent changes – the pintle design changed, the wheels increased in size, and some limbers became capable of carrying ammunition and small stores, boxes and men.



A. Block, or Trail.
B. Cheeks, or Brackets.
C. Axletree.
D. Ogee.
E. Trunnion holes.
F. Wheel.
G. Felly.
H. Spokes.
I. Nave.

J. Tire, or streak.
K. Rivets.
L. Tire, or Streak bolts.
a. Eye, or Capsquare bolts.
b. Capsquares.
c. Axletree bands.
d. Bracket bolts.
e. Transom bolts.
f. Trunnion plates.

g. Portfire clipper.
h. Locking plate.
i. Trail plate bolt.
k. Trail plate.
l. Trail plate eye.
m. Chain eye bolt.
n. Locking chain.
o. Breast, or advancing chain.
p. Trail handles.

q. Handspike shoe.
r. Handspike pin.
s. Handspike ring.
t. Axletree arms.
u. Dragwashers.
v. Nave hoops.
w. Elevating screw.
x Handles of elevating screw.
y. Elevating screw box.

Figure 128. Block Trail Field Carriage. (Boyd, A Manual for Naval Cadets (1857), pp. 257-8.)

Garrison Carriages

Common Standing (wood)

The common standing garrison carriage was made up of two wooden sides or brackets joined together near their fore ends by a transom; the latter was mortised into the brackets and they were bound together by an iron bolt passing transversely through them. The brackets were housed and bolted into two wooden axletrees. The ends of the axletrees were turned and four cast iron trunks, held in place by linch pins, were fitted on. A second long bolt was passed through both brackets a little behind their centre point. It supported one end of the stool bed while the other end was bolted to an upright which rested on the rear axletree. Quoins were placed on the stool bed by which the gun was elevated. Half circles to take the trunnions of the piece were cut in the upper edges of the brackets; initially capsquares, keyed in place over the trunnions, held the gun in place but in the nineteenth century these were found to be unnecessary for heavy guns. Various iron loops or eye bolts were attached to the carriage.

The origin of the common standing carriage was undoubtedly the naval carriage, with which it was almost identical, brought on shore early in the 1700s to be used in permanent works, but it is impossible to know precisely when it was distinguished from its sea-going counterpart.[1] In a notebook compiled at the Tower of London in the early 1720s, Lieutenant Thomas James recorded extensive details of travelling and ship carriages, but what he designated as a "Standing Carriage" was very similar in design to a travelling carriage, although quite heavy and equipped with "Plank Wheels."[2] There is a drawing of a carriage like a ship carriage but fitted with a semi-circular skid in place of the rear axletree and trucks which one student of eighteenth century artillery, Adrian Caruana, argues is of a land service garrison carriage.[3] Unfortunately the drawing was not titled, nor was there an accompanying table of dimensions or explanatory note.

The first detailed information we have on common standing garrison carriages originated in the 1750s and 1760s with the writing of John Muller and the notebook of S.P. Adye, one of Muller's students at the Royal Military Academy and a Royal Artillery officer (Fig. 129). Muller provided a table of "Dimensions of Ship and Garrison Carriages" from the 42-pounder to the 3-pounder which, he noted, were used in 1748.[4] (See Appendix Q.) He also supplied a formula whereby a carriage could be constructed for any gun if its dimensions were known.[5] (See Appendix S.) Also, although produced in 1792, there is a series of drawings by C.W. Rudyerd of a garrison carriage for a heavy 24-pounder.[6] The use of these sources, if applied with discretion, provide a solid basis for the reconstruction of garrison carriages in the latter half of the eighteenth century.

A few notes regarding the construction are in order, however. As previously described, a common garrison carriage was composed of two wooden brackets connected by a wooden transom and fitted into two wooden axletrees. Both Muller and Adye in their drawings placed the transom directly over the fore axletree and in the middle of the height of the brackets. This seems to be Muller's own construction, however, for he then wrote:

> though it is customary to place the fore part of the transom in a line passing through the centre of the trunnion holes, and so as to project the axletree by an inch, and the lower edge to touch the axletree.[7]

He did not describe the nature of the joints that he proposed for fitting the brackets into the axletrees and the drawings are not clear, but it appears that they were more

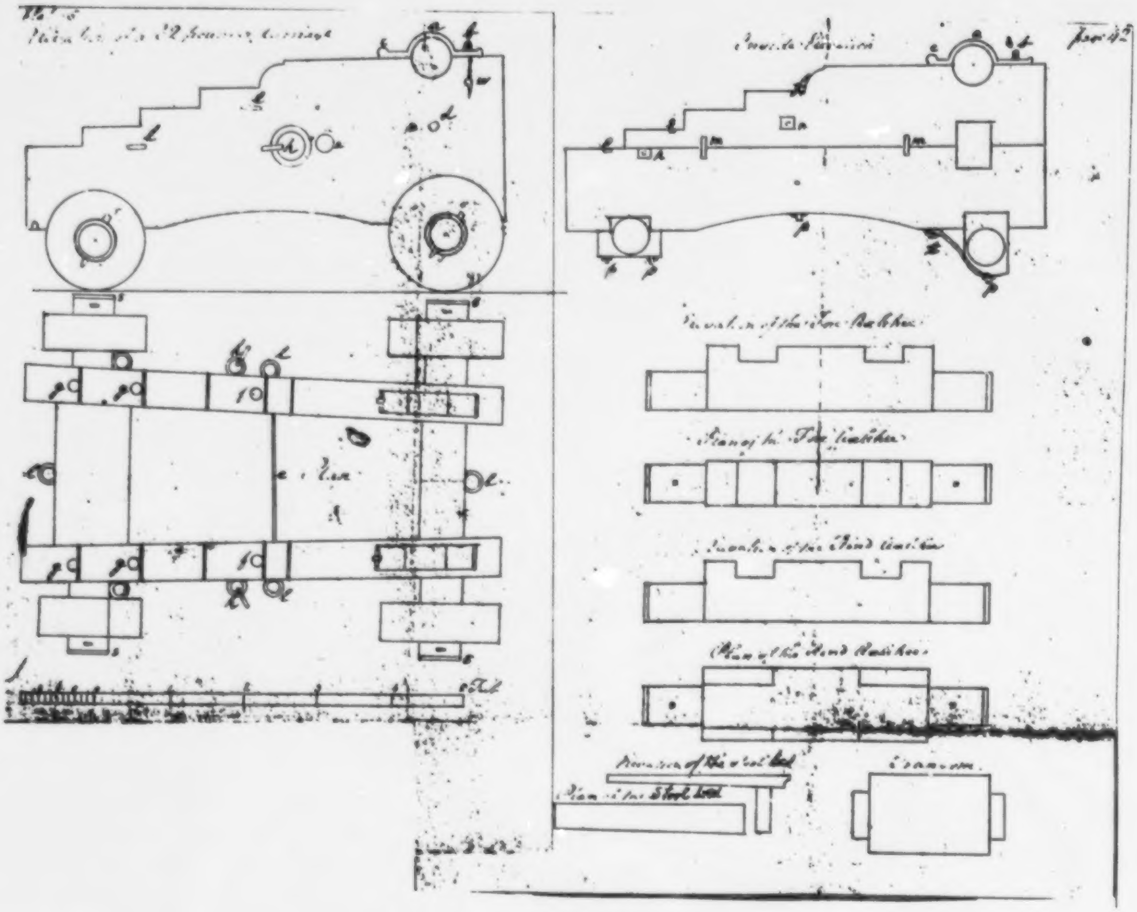


Figure 129. Elevation and Plans of a 32-pounder Garrison Carriage. (The Royal Artillery Institution, Woolwich, U.K., Adye (1766), Plate 5.)

complicated than a simple cut into the axletree the width of the bracket. Even so he claimed that his method was "...more simple, and yet equally as secure as the common manner."[8]

The brackets were pierced by two wrought iron bolts. One of these passed through both brackets and the upper part of the transom immediately below the trunnion holes. The other was positioned in the lower half of the brackets immediately under the highest of the four steps. A burr or washer was placed over the small end of both bolts which were then riveted into place. The lower bolt supported one end of the wooden stool bed which had a groove cut across its underside to hold it in position. The other end of the bed was supported by a wooden block mortised and bolted to it. The stool bed was removable, possibly to allow for an exaggerated elevation of the piece in unusual circumstances.

The brackets were usually composed of two pieces of wood held in place by two dowels and bolted through the top step. The bolt head was countersunk and the bolt was keyed into position. The hind axletree was also held in place by two bolts on each side which passed down through the lower two steps; their heads were also countersunk and they were keyed into place. An eye bolt passed downwards from in front of the trunnion hole through the bracket and fore axletree. To the rear of the trunnion hole a joint bolt, on which the capsquare pivoted over the eye bolt, passed downwards to emerge behind the axletree. An axletree band or stay was fitted over the ends of these bolts and keyed firmly into place. The capsquare was held closed by another key which was attached to the side of the bracket by a staple and chain and was inserted through the end of the eye bolt.

Both Muller and Adye drew ship carriages as illustrations in their writings which were very similar to garrison carriages but had different iron work:

> The garrison carriages have the same irons, excepting the breech rings, and their trucks are of cast iron; for which reason their axle-trees have copper clouts [plates] underneath, to diminish the friction of the iron against wood.[9]

If this statement was correct, a garrison carriage would have had two loops or eye bolts through each bracket, one through the transom, and another through the rear axletree. These were rivetted into place against square riveting plates set into the wood. Other iron work included traversing plates underneath the rear ends of the brackets to protect the wood from the working of the hand spikes. Iron hoops encircled the ends of the axletree arms to keep them from splitting. The trucks were held in place by iron linch pins which passed through the axletree arms.

This description of the construction of a common standing carriage remained generally correct for the next century or so, but there were certain changes in detail. Rudyerd's drawings of a standing carriage for a heavy 24-pounder made in 1792 (if they can be trusted) revealed some differences. It is clear from them that the joints of the axletrees and brackets were complicated, which may have been what Muller meant by his comment (quoted above) that his method of joining was simpler but as secure as what was commonly used. The stool bed appeared to be heavier; indeed that drawn by Muller and Adye looked too slight to support a heavy gun. Otherwise the wooden parts appeared to be about the same as they were 30 or 40 years before.[10]

The iron work was similar, but there were some interesting variations. Rudyerd clearly showed only two loops or eye bolts, one on each side of the carriage in the lower half of the bracket at about one-quarter of the length of the carriage from the rear. He also indicated that the ends of the transom and bed bolts were threaded and showed a peculiar round nut which resembled the head of the bolt; if this arrangement was used, it would have been inherently weak compared to riveting or the use of a more conventional nut. Although the rear axletree and centre bracket bolts were clearly intended to be keyed into place, the joint and eye bolts were shown with threads and nuts on their ends. Like those of Muller and Adye, Rudyerd's carriage was fitted with capsquares held in place by keys attached to the brackets by staples and chains. The axletree bands or stays shown were rather insubstantial pieces of curved wrought iron, but similar to those of the earlier period.[11]

The manner of securing the transom and bed bolts perhaps needs further comment. Because the nut was made to resemble the head of the rivet, it would need a special wrench to tighten it. Besides that, there was so little metal in the nut that at best it could only be tightened one or two turns. If the bolt was to be secured by a nut, why not use a conventional one? The only purpose immediately evident in this arrangement was aesthetic, that each end of the bolt appeared the same, hardly a convincing argument, it is suspected, to a carriage designer. It is difficult to credit this arrangement although it was clearly shown; such nuts did not appear before or thereafter. The usual method was to rivet these bolts.[12]

It is not clear precisely when capsquares were discontinued, but by the 1820s they were no longer in use for garrison guns (Fig. 130). Later commentators explained that they were heavy enough to remain in the trunnion holes when fired without the restraint of capsquares.[13] Boss headed bolts replaced the eye and joint bolts in front and behind the trunnion hole. These were probably keyed into place rather than riveted or nutted.[14]

Rudyerd clearly showed that the centre bracket bolt and the rear axletree bolts were keyed into place. This practice probably lasted till the late 1850s or early 1860s; in 1845 Fitzhugh wrote that all the axletree bolts were riveted.[15] In the mid-1860s the centre bolt was nutted, while the rear axletree bolts were riveted onto a countersunk burr or washer. If the rear trucks were damaged or shot away in action, the carriage could still be worked as if it were a rear chock carriage.[16]

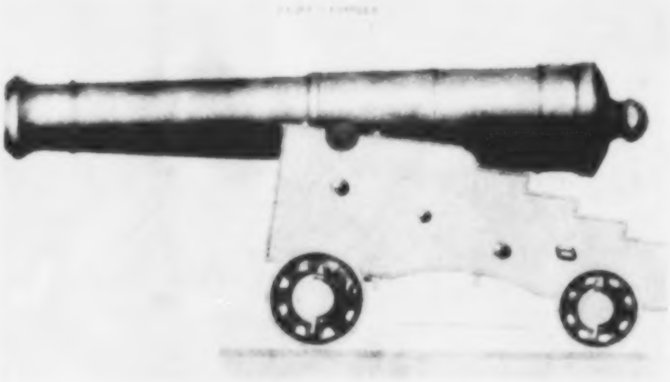


Figure 130. Heavy 24-pounder on a Garrison Carriage, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

Perhaps the most significant change in the design of the common standing garrison carriage was the introduction of the swing bed and elevating screw. Elevating screws had been standard equipment on field carriages since about 1750, but there is no evidence of their use on garrison carriages before 1800. By the first decade of the nineteenth century some form of screw had come into at least partial use, for in the spring of 1807 the Board of Ordnance ordered, among other items, that a 24-pounder carriage for a traversing platform with an elevating screw be sent to Quebec as a pattern for the construction of new carriages.[17] The pattern of screw may have been similar to the one which is partially visible in Shuttleworth's drawing in 1819 of a 24-pounder on a common standing carriage on a traversing platform (Fig. 131). Only one of the lever arms and the flat head are visible.[18] It was likely a threaded rod which moved up and down in a nut fitted into the rear axletree bed. The rod was rotated probably by four arms fitted into the cylindrical flat head on which the swing bed rested. It should be noted that the ends of three, not two, bolts are evident protruding from the side of the carriage; presumably the middle bolt supported the swing bed which was held in place by a groove in its fore end which fitted over the bolt. The outline of the bed in the drawing does not line up with the middle bolt, but this was likely a minor error in draughting; otherwise it is difficult to imagine the purpose of three bolts driven through the brackets. Indeed, later carriages with elevating screws had only two bolts.

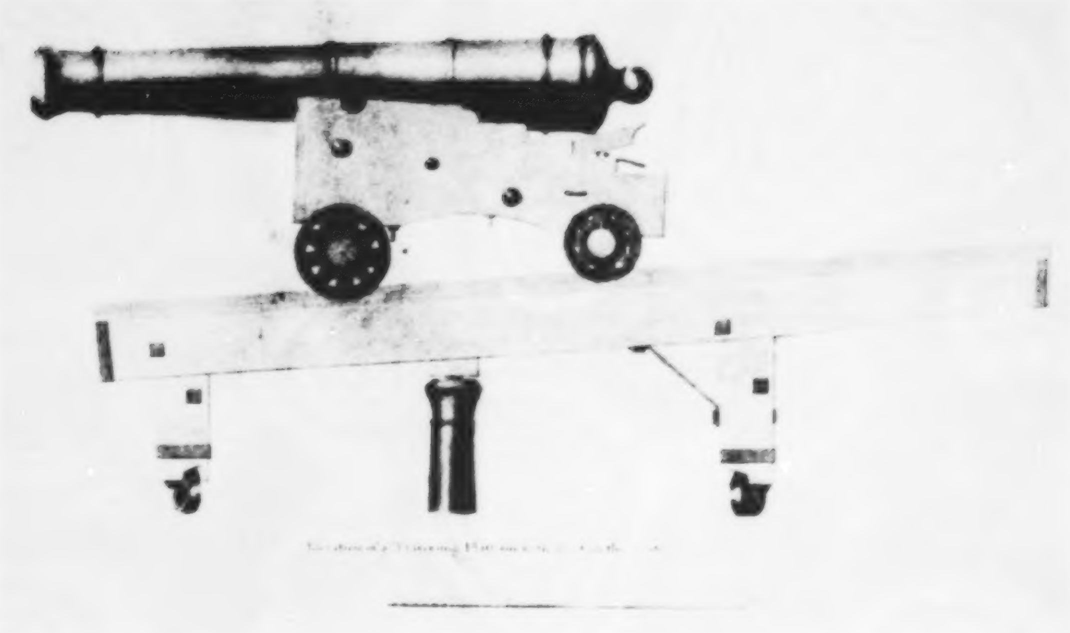


Figure 131. Heavy 24-pounder on Garrison Carriage on Traversing Platform, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

It is not clear when the elevating screw became standard issue for the common standing carriage. In 1845 Fitzhugh wrote that it was optional:

> There is a horizontal bolt passing through both transoms [sic] brackets which is intended for the swing bed, if the carriage have one and if it have not it serves to support the stool bed.
>
> Garrison carriages either have a stool bed and quoin or a swing bed elevating screw and quoin.[19]

By the 1860s, however, descriptions almost invariably mention the swing bed and elevating screw although dimensions for stool beds and blocks could still be found.[20]

A pattern of elevating screw different from that of the 1820s had been adopted by the 1860s. In 1859 Richardson described the elevating arrangement of a common standing carriage which he was disassembling:

> A stool bed rests on two Iron shoulders projecting from the inside of the front Transom, and on the head of the elevating screw... The elevating screw works in a female one of gunmetal let into the rear transom [sic]axletree ; it is provided with horizontal radiating teeth on the top and a movable bent lever with corresponding teeth. The head of the screw is hemispherical and rests in an oblong plated slot in the stool bed to admit of the play required for elevation and depression.[21]

This description leaves unclear the precise arrangement whereby the front of the swing bed was supported, but it does indicate that it was wood protected by metal where the head of the screw contacted it. Also, the screw did not shift or "oscillate" but rather the bed moved back and forth on its rounded head as the elevation of the gun was adjusted.

This pattern of screw proved unsatisfactory in some ways and was modified in 1860:

> The following are the improvements in the construction of this elevating screw, viz. —
>
> The teeth are cut on the edge, instead of on the face, of the ratchet wheel. This secures a better connexion of the lever, and causes less liability to slip.
>
> The key fastening the lever handle to its socket is placed in a more convenient position.
>
> The brass nut in which the screw works has been lowered about 3/8 of an inch, and the head of the screw lengthened, so as to obtain space for the lever handle to work, in any position in which the stool bed may be placed.[22]

The screw was named after its designer Mr. G. Smith, Assistant Superintendent of Machinery, Royal Carriage Department.

Until 1864 the swing bed of the garrison carriage continued to be made of wood, and the bed bolt, rather than merely supporting it, passed through it. The bolt was not riveted but fixed in place with a collar (washer) and key so that it could be removed if required. A batten equal in length to the inside width of the carriage was attached to the underside of the front end of the bed to prevent its moving from side to side. (This description of how the bed was supported is at variance with Richardson's in 1859.) An iron plate was set into the upper side of the bed for the breech to rest on if a quoin was not used, and "underneath is a sunk plate, with a slot in it for the head of the elevating screw to work in." Finally, a rivet of iron was driven through and across the rear end of the bed, presumably to strengthen it.[23]

The screw referred to was Smith's elevating. Its rounded head fitted into the slot on the underside of the swing bed and its threaded shaft worked in a brass nut set into the rear axletree. According to Miller in 1864, there were two varieties of elevating screws for garrison service — large, 16 inches long, and 1-1/2 inches thick, and small, also 16 inches long but 1-1/4 inches thick. The former was used in carriages for the 110-pounder Armstrong gun, the 10-inch and 68-pounder smooth bore guns; the latter with the 8-inch, 32-pounder, and smaller natures of ordnance.[24]

The Royal Carriage Department photo-lithograph of Smith's Elevating Screw, produced in 1870, showed two screws, one with a flat head and 2-1/4 inches in diameter, the other with a round head and 2-1/2 inches in diameter (Fig. 132). The former may be excluded from discussion because it was used for heavy siege guns, the base rings of which rested directly on the flat head. The latter was known as an oscillating screw which was fitted to rear chock and sliding carriages but not to common standing carriages.[25] But it may have been that by 1870 only one size of screw was being used, the only change necessary being the adoption of a square nut for the screw to work in.

In July 1865 the authorities directed that in future all common standing carriages were to be fitted with iron swing beds similar to those adopted for sliding carriages (Fig. 133). The only difference was that a groove had to be made in the underside of the bed for the head of the elevating screw, which did not oscillate, to work in.[26] The bed was attached to an iron staple bolted to and protruding from the transom; it was held in place by an iron pin attached to the transom by a chain and staple. A round hole was cut in the transom to allow a man to reach through to take out the pin if the bed was to be removed. The bolt which formerly supported the bed was retained, but its position was lowered so as not to interfere with the working of the swing bed and it was riveted in place.[27]

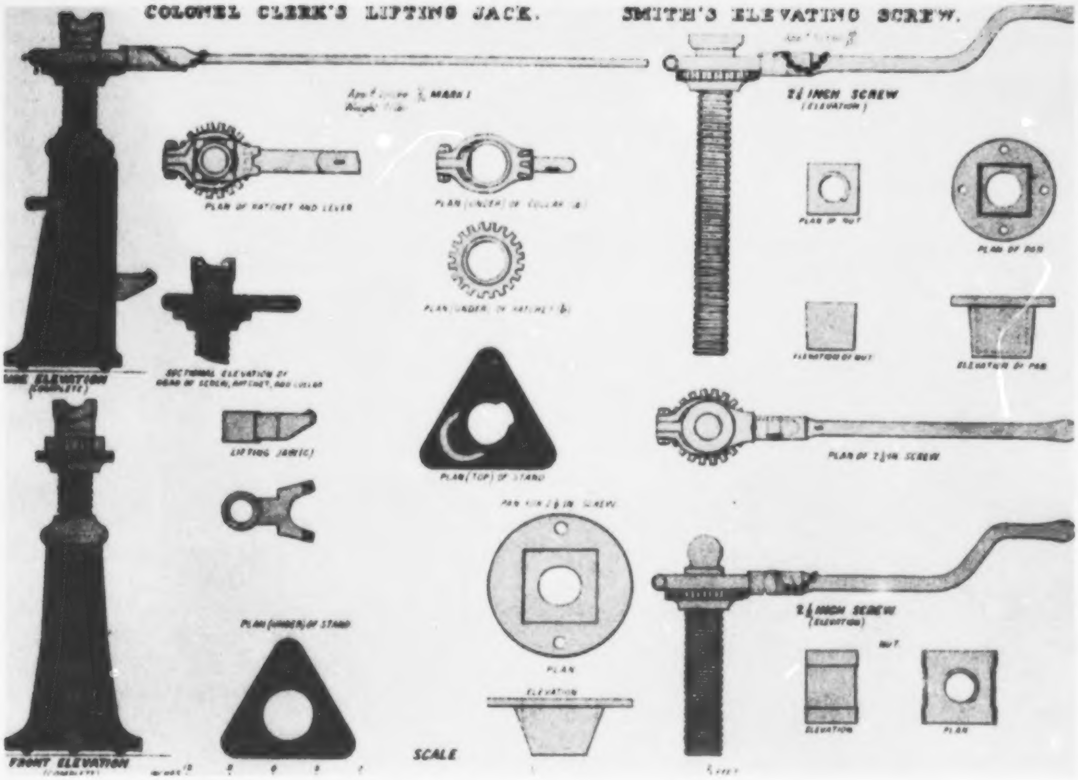

COLONEL CLERK'S LIFTING JACK.
SMITH'S ELEVATING SCREW.
2¼ INCH SCREW
(ELEVATION)
PLAN OF RATCHET AND LEVER
PLAN OF NUT
PLAN OF PAN
ELEVATION OF NUT
ELEVATION OF PAN
SIDE ELEVATION
(COMPLETE)
SECTIONAL ELEVATION OF HEAD OF SCREW, RATCHET, AND COLLAR
LIFTING JAW (C)
PLAN (TOP) OF STAND
PLAN OF 2¼ IN SCREW
PLAN (UNDER) OF STAND
PLAN
ELEVATION
2¼ INCH SCREW
(ELEVATION)
NUT
ELEVATION
PLAN
SCALE
FRONT ELEVATION

Figure 132. Colonel Clerk's Lifting Jack. Smith's Elevating Screw. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 75, September 1870.)

Common Standing (iron)

There were as well iron standing garrison carriages whose origins dated back to the mid-eighteenth century. According to one modern authority,

> The English type of four-wheeled carriage ... was based on that patented by Stephen Remnant, the Master Smith to the Board of Ordnance in 1761 (Pat. No. 765).[28]

They were reported to have come into service by 1800, but the first specific reference to their use occurred in Adye's Pocket Gunner in 1813:

> Standing gun carriages of cast iron have lately been introduced in the service for warm climates and situations not much exposed...

He gave the weight of iron carriages from the 32-pounder to the 6-pounder and mentioned experiments with an 18-pounder iron carriage at Sutton Heath in 1810.[29]

While they resisted the weather well, it was found that in battle if they were struck and shattered by a ball their fragments were as dangerous as enemy fire, killing and maiming the gun crews nearby and destroying the neighbouring carriages as well. Moreover, once they were damaged, they were almost impossible to repair

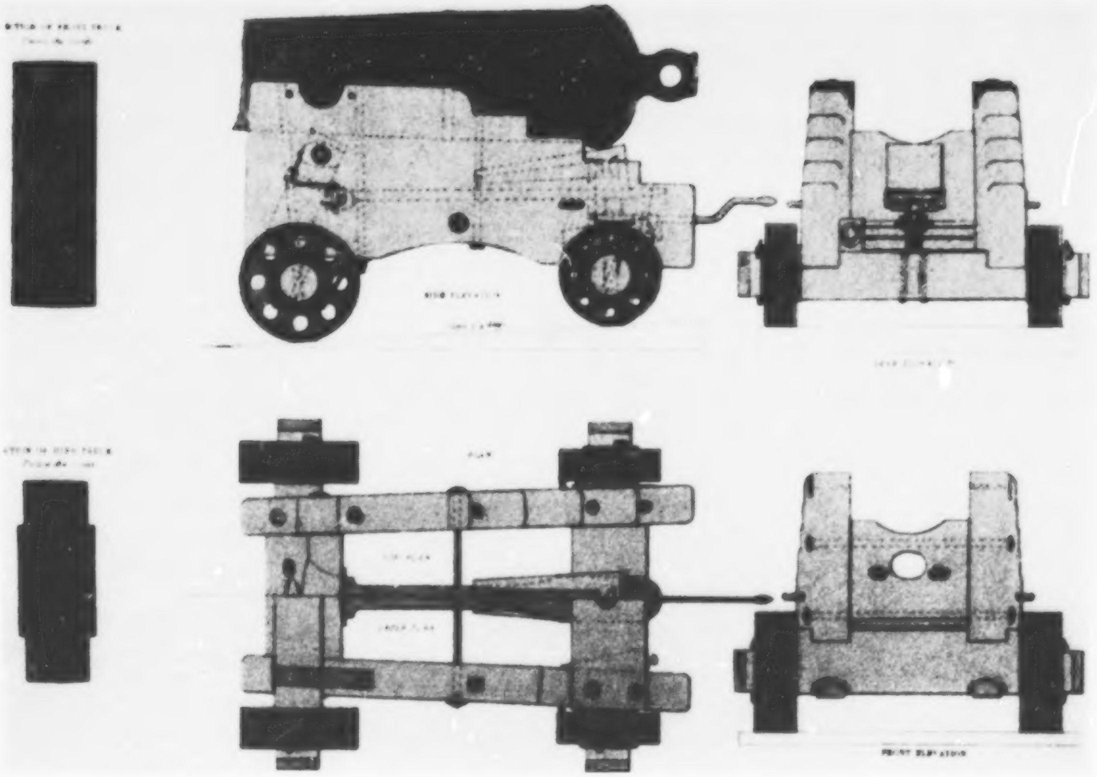


Figure 133. Garrison Standing Carriage for 32-Pr. 56 or 58 Cwt. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 63, June 1870.)

on the spot, unlike wooden carriages. Consequently, the Master-General and Board of Ordnance issued an order on 9 March 1810 regulating their use. They were:

> "to be placed in such parts of fortifications as are least exposed to the enemy's fire; and in sea batteries to which heavy ships cannot approach nearer than 1000 yards."[30]

Eventually they came to be restricted "...to saluting batteries and those fronts of fortifications which are not liable to sudden attacks or enfilading fire..."[31] Wooden carriages were to be kept in store to replace them if attack was imminent.

Iron garrison carriages were made for all calibres of guns from the 42- to the 6-pounder and according to Miller, even for the 8-inch gun, but other than tables of weights dating from 1813 to the 1860s, details of their construction are lacking until the publication of a drawing and some dimensions in the Aide-Mémoire in 1846.[32]

Maximum height at front above platform	3 ft. 1 in.
Diagonal length	
32- and 24-pr.	6 ft.
18- and 12-pr.	5 ft. 9 in.
9- and 6-pr.	5 ft. 4 1/2 in.

In 1852 Straith published a scale diagram with dimensions.[33]

Maximum height at front above platform	3 ft.
Distance, centre to centre, between axletrees	4 ft. 3 in.
Length of bracket	5 ft. 9 in.
Length of axletree	4 ft. 3 in.
Diameter of trucks	1 ft. 6 in.

He did not specify, but these appear to be dimensions for the 24- and 32-pounder iron carriages. It is possible that the length of the axletrees remained the same in all calibres, but obviously the position of the brackets would have to vary to accommodate the different diameters of guns.

A cast iron garrison carriage consisted of two open-frame iron brackets fitted over two iron axletrees, held together by two bolts, and resting on four iron trucks. The extremities of the axletrees were cast round to take the trucks. The brackets were cast with square holes to fit around the axletree beds, front and rear; iron shoulders on the bed held the axletrees at the proper distance apart and iron keys driven through the axletree secured them firmly against the shoulders. They were bolted at the top underneath the trunnion holes and at the middle. These bolts were secured by hexagonal nuts at each end. The middle bolt supported one end of an iron stool bed; the other end fitted into an iron support which rested on the rear axletree. The front and rear trucks were the same diameter, 16 inches, and were held in place by iron linch pins.[34]

There are a number of iron garrison carriages in the Parks system — namely, carriages for 24- and 32-pounders on rue des Remparts in Quebec City, for 24-pounders in St. Andrew's, N.B., and for 9-pounders at Fort Amherst, P.E.I. These carriages are all basically of the same design, but there are variations. One 24-pounder carriage at Quebec City, which may be the oldest, is much more angular than the others and has four steps in its brackets (Fig. 134); the other 32- and 24-pounder carriages have three steps (Fig. 135). The 9-pounder carriages at Fort Amherst have only two rather long steps, but otherwise they seem similar to the design published in the Aide-Mémoire (Fig. 136). Without tables of dimensions or other drawings it is impossible to come to other conclusions about design, although the small changes in weights recorded between 1813 and the 1860s probably indicate variations from year to year.

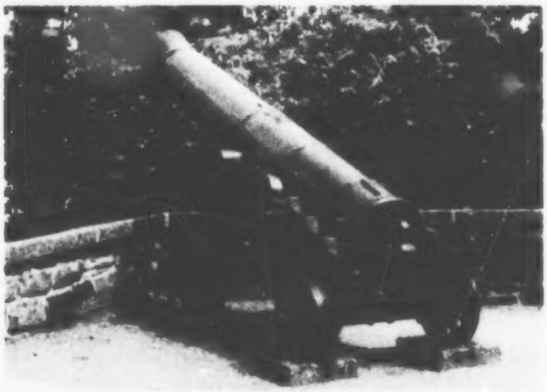


Figure 134. Iron Garrison Carriage for a 24-pounder Gun, weight: 18 hundred-weight 3 quarters 14 pounds. (Parks, rue des Remparts, Québec.)

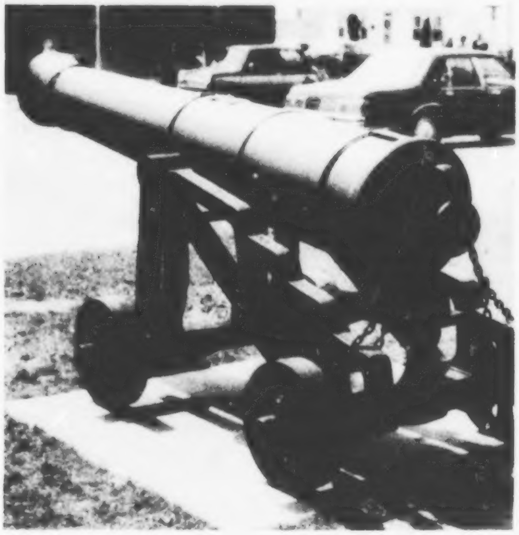


Figure 135. Iron Garrison Carriage for a 24-pounder Gun, weight: 21 hundredweight 18 pounds. (Near Town Hall, St. Andrew's, New Brunswick.)

Figure 136. Iron Garrison Carriage for 9-pounder Gun, weight: 14 hundredweight 2 quarters 20 pounds. (Parks, Fort Amherst National Historic Park, Charlottetown, Prince Edward Island.)

Rear Chock

A rear chock carriage was very similar to a common standing carriage, except that instead of a rear axletree and trucks it was fitted with a chock or block of wood which rested upon the platform. It was designed to control more effectively certain guns which recoiled quite violently. The design probably originated with carriages upon which 8-, 10-, and 5-1/2-inch iron howitzers had been mounted for a number of years. It is not clear when it was first used for guns, but there was no mention of it in the Aide-Mémoire in 1853. The first specific reference discovered was in Griffiths' Artillerist's Manual in 1859.[35]

The construction of a rear chock carriage is clearly illustrated in a Royal Carriage Department (R.C.D.) photo-lithograph dated May 1870 (Fig. 137).[36] The construction of the brackets and front axletree was the same as of the common standing carriage. The chock was fitted to the brackets in much the same way as the rear axletree which it was replacing. The R.C.D. plate shows two bolts driven through the lower two steps of the brackets; however, another source, circa 1864, indicated that, because the chock was wider than the axletree, three bolts were used which passed through the three lower steps. To the left of centre in the rear of the chock a handspike iron was fixed in the bottom of which there was a socket into which the double roller handspike was fitted to raise the carriage and run out the gun. There were also sockets attached under the rear of each bracket of the 68-pounder and 10-inch carriage. An eye bolt was attached to each bracket and to the right side of the rear of the chock. The swing bed was made of iron and was attached by a pin to a staple bolted through the transom. The carriage was equipped with Smith's oscillating screw. Its rounded headed fitted into a hollow in the underside of the bed. The threaded rod worked in the oscillating nut which fitted into a pan set into the chock; the nut was so shaped that it could rock back and forth as the gun was elevated or depressed.[37]

Rear chock carriages were constructed for 10-inch, 68-pounder, 8-inch, 32- and 24-pounder guns; unfortunately different sources indicate different models of 32- and 24-pounders. The carriage for the 8-inch gun was approved to be used for the defence of flanks and caponnières on 25 February 1860 and the pattern for the carriage of the 68-pounder, 95 hundredweight, or 10-inch, 87 hundredweight, guns was sealed on 27 April 1864.[38] A drawing of this latter carriage has not been found, but dimensions of rear chock carriages were published about 1864 (see Appendix Y).[39]

Sliding Carriages for Dwarf and Casemate Traversing Platforms

In the 1840s when dwarf and casemate traversing platforms were introduced, sliding carriages were developed to replace the common standing carriages which had been mounted on the old long-legged common traversing platforms. Written descriptions of the new carriages date from the 1860s, but there are two drawings from 1846 and circa 1850 of a sliding carriage on a dwarf traversing platform.[40] The brackets and transom design and assembly were the same as that of the common standing carriage, but a block of wood had been substituted at the front and rear for the axletrees and trucks. Each block was connected to the brackets by two bolts and

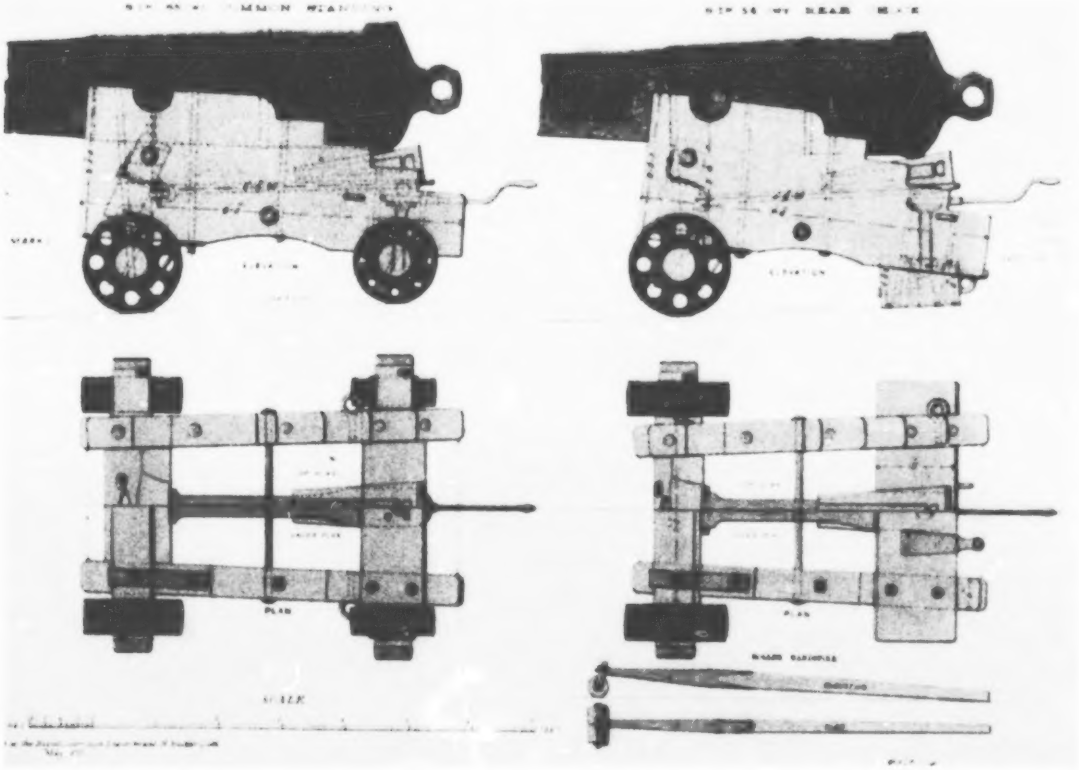


Figure 137. Garrison Carriages. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 62, May 1870.)

there were no capsquares. The blocks, which rested on the side pieces of the platform, were made deeper in the centre to keep the carriage in place as it recoiled. (For illustrations see chapter on Traversing Platforms.)

In order to run the gun out, an ingenious device was employed. Two gun metal trucks fitting into iron brackets were bolted to the front ends of the brackets, the trucks being slightly off the platform. Two eye bolts were driven through the rear block beneath the ends of the brackets; above them two sockets were attached with screws into the ends of the brackets. The heads of two roller handspikes were inserted into the eye bolts, the handles pulled down to the level of the side pieces, and two pawls, attached to the head, pivoted up and into the sockets. When the handles of the handspikes were lowered, the rear of the carriage was lifted off the platform and the metal trucks at the front brought in contact with the side pieces, thereby turning the sliding carriage into a four-wheel vehicle; the pawls kept the handspikes down as the carriage was run out.

The elevating device consisted of a wooden swing bed, elevating screw, and quoin. The front end of the bed was supported by a bolt, which may have been inserted through it; if so it would have been keyed into place, not riveted. The screw appears to have been the same as that which was fitted to some common standing carriages — a threaded shaft surmounted by a cylindrical head into which were inserted four rods whereby the screw was turned. The shaft worked in a square nut fitted into the rear block of the carriage. It is difficult to tell from the drawings, but it seems unlikely that the screw "oscillated" as it did in the 1860s; however, there appears to be a hemispherical projection, probably of metal, from the underside of the bed which rested on the head of the screw and protected the bed as it was raised or lowered.

By the 1860s the essentials of the sliding carriage had not changed, but there were certain differences in detail. The blocks, which were said to be of African oak or sabicu, were wider especially the rear block which was held in place by three bolts. The blocks were made in two parts; the guiding section, which was 2.5 inches narrower than the distance between the side pieces of the platform, was bolted to the underside of the front block to take the bearing of the carriage on the iron plates of the platform as it recoiled. (It is not apparent why friction plates were not attached to the rear block as well.) The method of running the carriage out remained the same but the roller handspike, or truck lever, may have been more sophisticated. When the front rollers were not engaged they were 3/16 inch off the surface of the platform; the truck levers raised the carriages two inches which was sufficient to engage the rollers.

It was found that controlling the carriage as it was run out was difficult; consequently an eye bolt was bolted to the rear of the rear block to which a preventor rope was hooked. It was wound three or four times around a bollard fixed into the left side of the platform by which the carriage could be restrained; there was a mark on the rope indicating when the carriage was almost run out. The eye bolt also took the pintle of the transporting dilly and a hole drilled through the front block took an axletree for wheels when the carriage was to be moved. It was also found that the rear block was damaged by the iron stops set into the platform when it recoiled or was pulled back by tackle during practice. To prevent this damage two plates of iron about 1/16-inch thick were fitted to each side of the rear block where it met the stops.[42]

In certain carriages it was found that the recoil was so violent that a brake or wooden compressor was necessary. In October 1862 it was ordered that the wooden compressor which had already been developed for the 110-pounder Armstrong gun was to be adopted to use with the 10-inch, 8-inch, and 68-pounder sliding carriages.[43]

> The compressor consists of two cheeks, ... of elm, held together by two guide bolts ... in such a manner that they fit tightly in one cheek but slide easily in and out of the other, being prevented sliding beyond certain limits by nuts. An iron eccentric is fitted between the cheeks in metal bearings, through which a square bolt passes from the under side: over the bolt resting upon the upper surfaces of the cheeks an iron disc ... is placed, and above it again a lever handle, with fall and toggle, is nutted on the bolt. On the iron disc are two slotted holes ... through which a small iron stud ..., on each cheek projects. Two short iron plates project on each side of the compressor and serve to support it as it lies between the sides of the platform beneath the carriage: its lever is on the right, and when drawn to the rear, by means of the eccentric, presses the sides of the compressor against the sides of the platform, fixing it therefore more or less to the latter: the carriage however to recoil must carry the compressor with it and therefore the recoil is checked. To remove the compression for running up, the lever is drawn to the front, when the slots in its iron disc working on the studs in the cheeks bring the latter together and free of the platform.[44]

The dimensions of the sealed patterns given in 1862 were:[45]

	Length		Width		Depth	Weight	
	ft.	in.	ft.	in.	in.	qrs.	lbs.
10-inch or 68-pdr.	2	4 1/2	1	8 7/8	4	3	21
8-inch of 52 cwt.	1	10	1	8 7/8	4	3	14

Elevation was still accomplished by a swing bed, elevating screw, and quoin, but major changes had been made. Sometime before 1860, an iron stool bed had been adopted that was pinned to an iron staple bolted through and projecting from the transom. A hole was cut in the transom to allow a man to reach in to withdraw the pin to remove the bed; the staple was attached to the transom by a chain and staple. The underside of the bed had an indentation in it to take the head of Smith's oscillating elevating screw. As the gun was depressed or elevated this screw worked in a gunmetal nut which was so shaped that it could rock back and forth in a pan fitted into the rear block of the carriage. This arrangement was the same as for the rear chock carriage.

There was as well certain other iron work. Two loops were bolted on each side to take tackle. There was a rivet just before and behind each trunnion hole to prevent the wood splitting. All the bolts in the carriage were nutted and the nuts of those bolts which passed through the blocks were countersunk. Finally there was a loop for the priming wires.[46]

The casemate sliding carriage is similar to the dwarf sliding carriage except that it had lower brackets.

Mortar Beds (wood and iron)

Land service mortar beds in the eighteenth century were massive blocks of wood hollowed out to receive the trunnions and breech of the mortar. Mortar beds were obviously in use before, but the first detailed specifications found were published by Muller in 1757 and repeated, more or less, in Adye's notebook in 1766.[47]

These and accompanying drawings (Fig. 138) suggest that the beds for 8-, 10-, and 13-inch mortars were made up of an upper and a lower bed, but according to Muller and Adye they were composed of four pieces of wood.

> The land mortar beds are here made of solid timber, consisting generally of four pieces ... The joint of the two pieces of the upper bed, in the 13, 10, and 8 inch beds, are so contrived as not to be directly over the joint of the pieces in the under bed.[48]

In 1779, Smith wrote that they consisted of two pieces.[49] The suggestion of four pieces seems curious, but the beds were pierced by both horizontal and vertical bolts. Clearly the vertical bolts held the upper and lower beds together. The horizontal bolts must have held the bed together transversely; for what other reason would so many transverse bolts have been necessary?

Muller, Adye, and Smith indicated that the depths of the trunnion holes were equal to their width; thus the trunnions were sunk completely in the bed and the capsquares were flat pieces of iron bolted unto the mortar bed. Muller appeared to find this arrangement unsatisfactory, for he wrote:

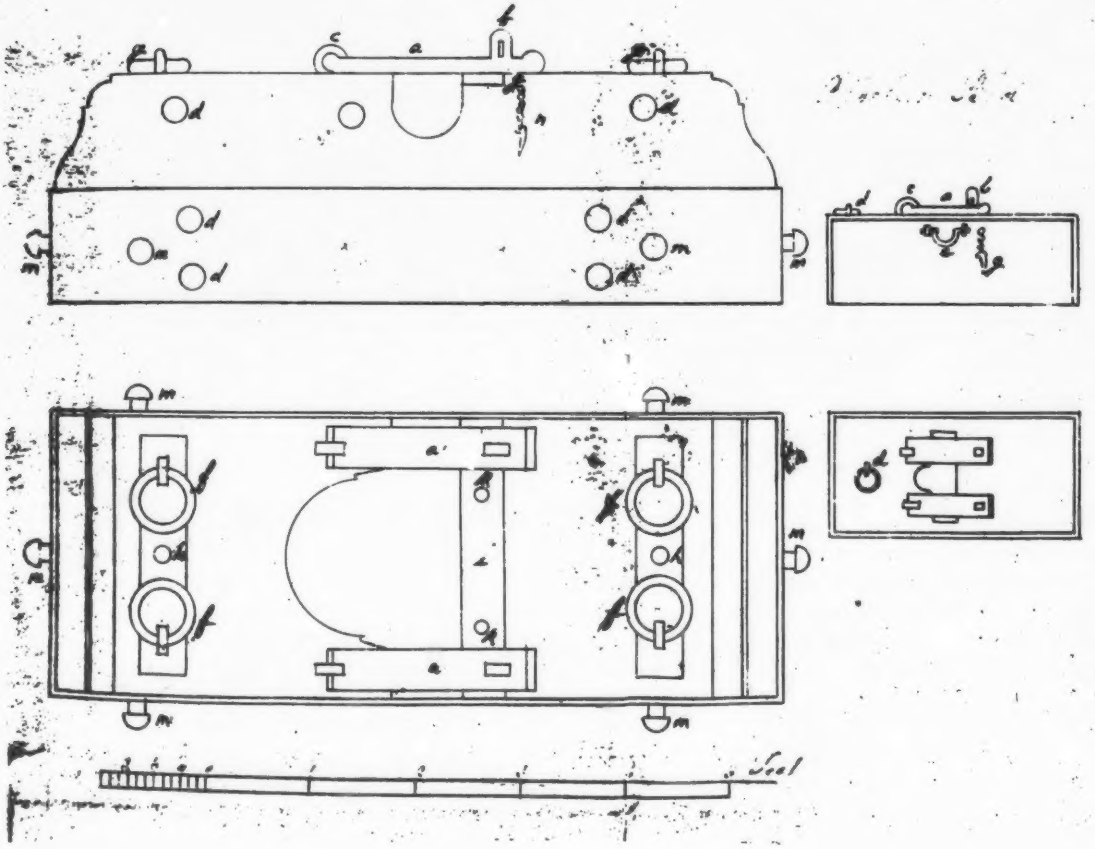


Figure 138. Plan and Elevation of the Beds for a 13-inch and a Coehorn Mortar. (The Royal Artillery Institution, Woolwich, U.K. Adye (1766), Plate 9.)

> We suppose these mortars so fixed in their beds as to be moveable [sic], quite contrary to the present practice under-lining mine , and that they may be raised from an angle of 10 degrees to any under 90; for which reason the depth of the trunnion hole is not equal to its diameter, and the cavity in the bed is to be made in such a manner as to receive the wedges by which the mortar is raised.[50]

This foreshadowed the later practice clearly shown in the Rudyerd drawings in which the trunnion hole depth is 1/2 the diameter of the trunnions. British practice, however, seems to have been to fire mortars only at an elevation of 45 degrees.

Coehorn and royal mortars were simply single blocks of wood hollowed out to take the mortar. The iron work was much simpler than for the heavier weapons.

Except for the number of pieces composing the heavier beds, there were no substantial differences between the dimensions set down by Muller, Adye, and Smith in the 1750s, '60s, and '70s (see Appendix AA). A comparison with the 13-inch bed that Rudyerd drew in 1791 or 1792 shows that there were some minor differences between the 1770s and the 1790s.[51] The general appearance was the same, but there were minor differences in the lengths and widths. The overall height was about the same, but rather than the two beds being equal in height, the upper bed was the deeper of the two in the 1790s. As previously noted, the trunnion holes were the depth of 1/2 diameter of the trunnions, and the capsquares, of course, were shaped appropriately. Previously they hinged, but these appear to have been held on by two eye bolts and keys and to have lifted off entirely. One set of the eye bolts was denoted joint bolts, but they did not have the latter's appearance. For whatever reason, the number of transverse bolts had increased; 10 were shown. Otherwise the iron work was more or less the same. There was one additional piece of woodwork, attached in front of the cavity, which appeared to support the mortar; whether it was movable to adjust the elevation is not clear. Since Rudyerd made no drawings of any other mortar beds, it is impossible to compare the beds of the other calibres in detail. Later wooden beds drawn by Shuttleworth, circa 1820, were very similar to Rudyerd's drawing, although that of an 8-inch mortar bed showed only one transverse bolt.[52]

In the first decade of the nineteenth century, Adye published dimensions which were quite similar to those of 50 years before,the major difference being in the length of the 10-inch mortar bed:[53]

Calibre	**Weight**			**Length**		**Breadth**		**Height**	
in.	**cwt.**	**qr.**	**lb.**	**ft.**	**in.**	**ft.**	**in.**	**ft.**	**in.**
13	21	2	7	7		2	6	2	3
10	10	0	20	6	6	1	8	1	10
8	6	0	20	4	2	1	7	1	7 1/2
5 1/2	1	0	22	2	9	1	4	0	10
4 2/5	0	3	11	2	4 1/2	1	2	0	9

A difference of a foot in the length of the 10-inch bed is considerable; it is possible that a typographical error has been made and 6 feet 6 inches substituted for 5 feet 5 inches. Adye did not indicate that the bed was made in two pieces, but other sources did; the lower part was of oak and the upper of elm.[54] By this time, however, iron mortar beds were coming into service for the three largest mortars and, although Mould noted the weight of wooden land service beds in 1825, they probably became obsolete before 1830.[55]

There seem to have been two designs of iron mortar beds. The first, introduced by Blomefield before 1800, perhaps as early as the late 1780s, was cast as a single unit, except for the capsquares which were bolted into place (Fig. 139).[56] With minor variations, this design was published in the Aide-Mémoire in the mid-1840s.[57] A second design, which may have been introduced in the second half of the 1820s, was cast in pieces and bolted together; its capsquares slipped on and were held in place by vertical pins dropped into the brackets (Fig. 140). This design was also illustrated in the Aide-Mémoire of 1846.[58] The second design was also much lighter than the first.

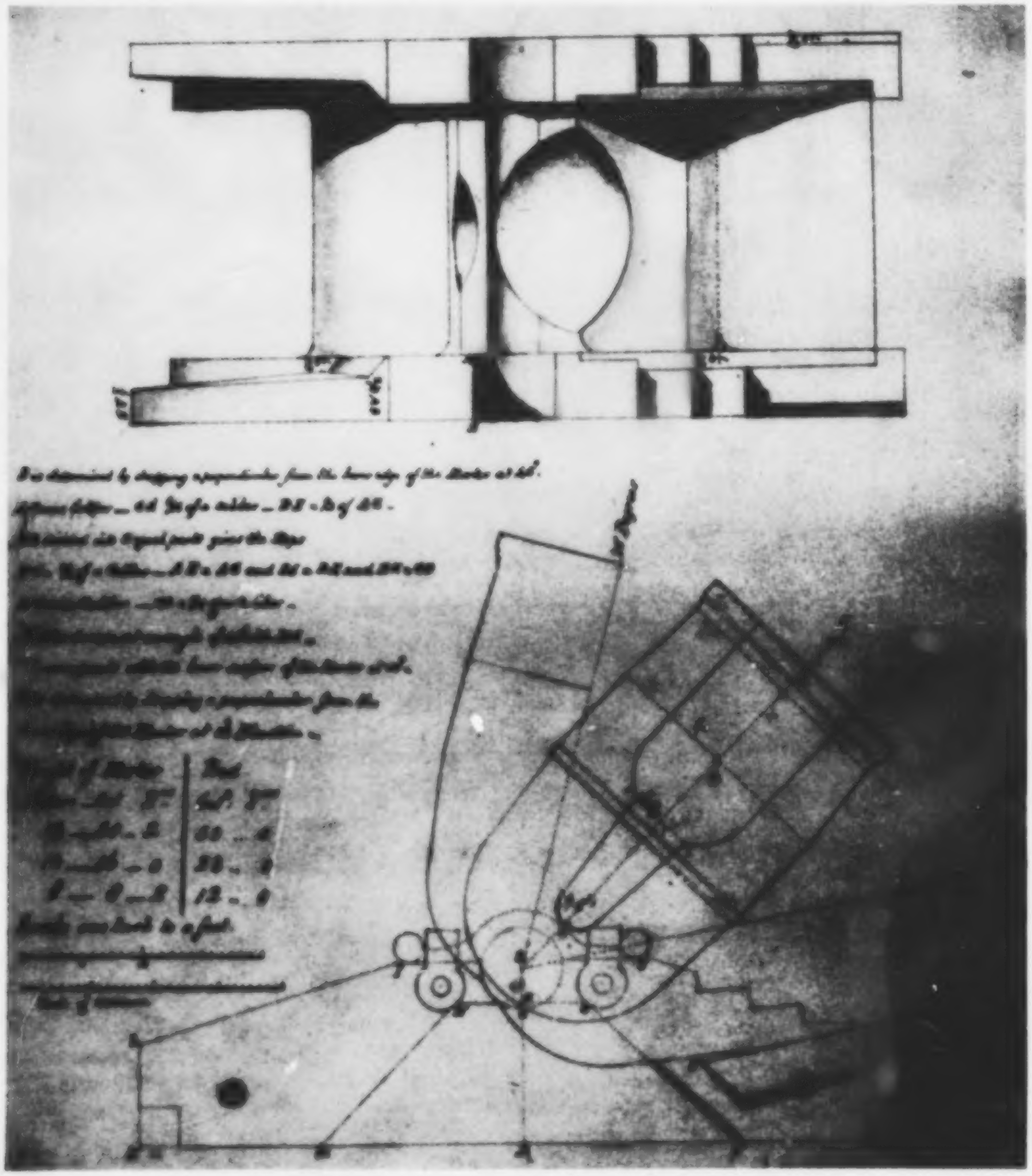


Figure 139. General Construction of Land Service Iron Mortar Beds. Colonel Blomefield's. (Parks, Fort Malden National Historic Park, Adye, Notebook, circa 1800.)

The iconographic evidence is clear, but the literary evidence is confusing and may indicate design changes within the two basic categories. Information up to 1825 was consistent:[59]

Calibre	Weight	Length		Breadth		Height*	
in.	cwt.	ft.	in.	ft.	in.	ft.	in.
13	50	6	3	3	1	1	6
10	23	4	8	2	4	1	1 1/2
8	12	4	0	1	11		11

* without capsquares

These weights and dimensions clearly referred to the beds designed by Blomefield. But three years later Spearman published dimensions for Old Pattern and New Pattern iron beds:

Calibre	Weight			Length		Breadth		Height	
in.	cwt.	qr.	lb.	ft.	in.	ft.	in.	ft.	in.
Old Pattern									
13	48	3	11	5	8	3	4	2	1
10	21	3	19	4	5	2	7	1	7
8	11	1	10	3	6	2	1	1	3
New Pattern									
13	33	0	1	5	5.5	3	10.5	2	1
10	16	1	16	4	4	3	4.5	1	7
8	7	2	27	3	3	3	1	1	3

There was also a notation that "The breadth and length of each bed...is measured from the extremities of the traversing bolts."[60]

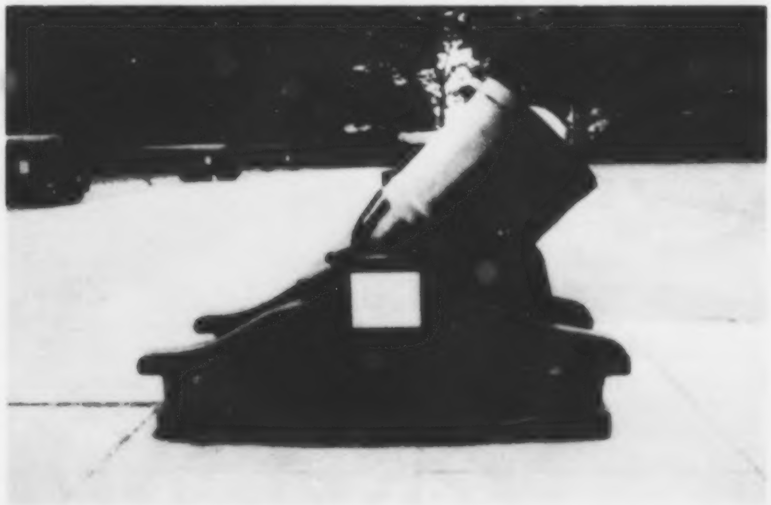


Figure 140. Iron Bed for 10-inch Mortar. (National Maritime Museum, London, U.K.)

It is tempting to conclude that the Old Pattern was the bed designed by Blomefield, for the differences in weights are insignificant, but the variations in the dimensions need some explanation. The increased height may be accounted for if the capsquares were included in the measurement. At first sight, the notation regarding measurement might account for the increased width, but the differences of 2 or 3 inches would mean a traversing bolt 1 or 1-1/2 inches long, lengths which seem unlikely. Also, if Spearman's Old Pattern dimensions for a 13-inch mortar bed are compared with dimensions scaled from the Aide-Mémoire drawing of a 13-inch mortar bed in 1844, they are found to be the same, if the notation about measuring from the extremities of the traversing bolts is ignored. Since a second design of mortar, which was slightly broader and shorter, was replacing Blomefield's original design by at least 1820 (see section on mortars), it seems likely that the Old Pattern bed referred to by Spearman was designed for this newer mortar. It also appears clear, given the evidence of the drawing of the 13-inch iron mortar bed in the Aide-Mémoire of 1846, that the change was in dimensions and not in basic appearance: the bed was still cast as a unit and the capsquares were bolted on.

Spearman's New Pattern mortar bed was a change in design, if the drawing of a New Pattern 10-inch bed in the Aide-Mémoire of 1845 is accepted as essentially the same. Moreover, the difference in weight between the Old and New Pattern suggests a radical change in design. It was cast in parts and bolted together and the capsquares were designed to slip on and to be held in place by vertical pins. It is not clear if the 1828 New Pattern bed was only an improvement in design or if it originated in the development of the new mortars to be introduced shortly by General Thomas Millar. Probably the former explanation is correct for the new mortars do not seem to have come into service until the 1830s.

Sources, both iconographic and literary, indicate that there were changes in dimensions in the mortar beds, perhaps to accommodate the shift to the Millar mortars or perhaps only as design improvements. During the 1840s and '50s in the various editions of his Artillerist's Manual Griffiths published tables of dimensions for both Old and New Pattern iron mortar beds:

Calibre	**Weight**			**Length**		**Breadth**		**Height**	
in.	**cwt.**	**qr.**	**lb.**	**ft.**	**in.**	**ft.**	**in.**	**ft.**	**in.**
Old Pattern									
13	35	2	22	5	5.5	3	1	2	1
10	16	1	16	4	4	3	1	1	7
8	7	2	27	3	3	3	1	1	3
New Pattern									
13	31	0	0	6	1	3	2.75	2	0.5
10	15	2	22	4	4	3	1	1	7
8	7	2	10	3	3	3	1	1	3

With the exception of the weight of the 13-inch bed and the widths of the 13- and 10-inch beds, the table of Old Pattern dimensions duplicates the New Pattern table published by Spearman in 1828. All three beds were said to be the same width, 3 feet 1 inch, which seems unlikely. The table of New Pattern dimensions indicated changes had taken place, but the relatively slight changes in weight indicated that these were not radical. The greatest change occurred to the 13-inch bed which was longer, wider, and slightly lower; the length, width, and height of the 10- and 8-inch beds remained the same although the lessening weight indicated some design changes. It seems likely that the appearance of these Old and New Pattern beds was essentially the same.

The evidence of Griffiths indicated that there were changes to the beds, but the details that he gave should be looked at skeptically. It seems unlikely that the 10-and 8-inch beds would be the same width or that the New Pattern 13-inch bed would be only 1-1/4 inches wider. Griffiths' dimensions can be checked to some degree by reference to the drawings in the Aide-Mémoire. In the 1845 edition there is a drawing of New Pattern 10-inch bed the dimensions of which when scaled from it matches very closely Griffiths' dimensions for the same calibre bed, if the width is taken to incude the length of the traversing bolts. Griffiths's Old Pattern and New Pattern 10-inch bed remained the same size, but the Aide-Mémoire in its second edition in 1853 published a second drawing of a 10-inch bed which is about 9 inches longer although its width and height remained about the same.[62] An example of this bed may be seen outside the National Maritime Museum, Greenwich.[63] The second edition of the Aide-Mémoire also published a 13-inch New Pattern bed whose length of 6 feet 1 inch is the same as Griffiths's New Pattern, but whose width including the traversing bolts is about 3 feet 9 inches. (The height is about the same.)

In summary, the first iron beds, introduced by Blomefield before 1800 were cast as single units with the capsquares bolted on. This design may have undergone minor modifications to accommodate a new design in mortar. In the late 1820s a new design of bed was introduced, in which the parts were cast separately and bolted together; the capsquares slipped on and were pinned in place. This design was considerably lighter. It too seems to have undergone minor modifications to accommodate the third design of mortar introduced in the 1830s.

Until 1859 the same beds were used for both siege and garrison service, the mortars and beds being transported on wagons. In December of that year a travelling carriage was approved for the 8-inch mortar for naval service in China.[64] Its precise nature is not known, but it must have inspired Lt.-Col. Clerk to design travelling carriages first for the 8- and 10-inch mortars and then for the 13-inch mortar which were approved in December 1860 and February 1861 respectively (Figs. 141, 142, and 143).[65] These were wooden beds fitted with an axletree and wheels and with a trail to be attached to the limber. When the mortar was to be readied for action it was tipped forward onto its end which lifted the wheels slightly off the ground; the wheels were then removed and the mortar brought back to a horizontal position ready for firing. Their natures may be seen in the three Royal Carriage Department plates.[66] The only change in design was the enlargement of the tires for the 8-inch carriage from 2-1/4 inches to 3 inches in December 1862.[67]

Coehorn and Royal mortar beds were simple rectangular blocks of wood, hollowed out to receive the trunnions and breech of the mortar, and fitted with a minimum of iron work. Although minor details and dimensions changed, this basic description was as true in 1860 as it had been in 1750. About 1760, the mortar was held in place by two capsquares bolted to the bed by two joint bolts and two eye bolts. As well, there was a ring attached by a bolt toward the front of the bed; its purpose is not clear. On each side there were handles by which the bed could be carried (Fig. 138).[68]

The dimensions given in Adye's manual of 1801 were more or less the same as in 1760:[69]

Calibre	Weight			Length		Width		Height	
in.	cwt.	qr.	lb.	ft.	in.	ft.	in.	ft.	in.
5 1/2	1	0	22	2	9	1	4		10
4 2/5		3	11	2	4.5	1	2		9

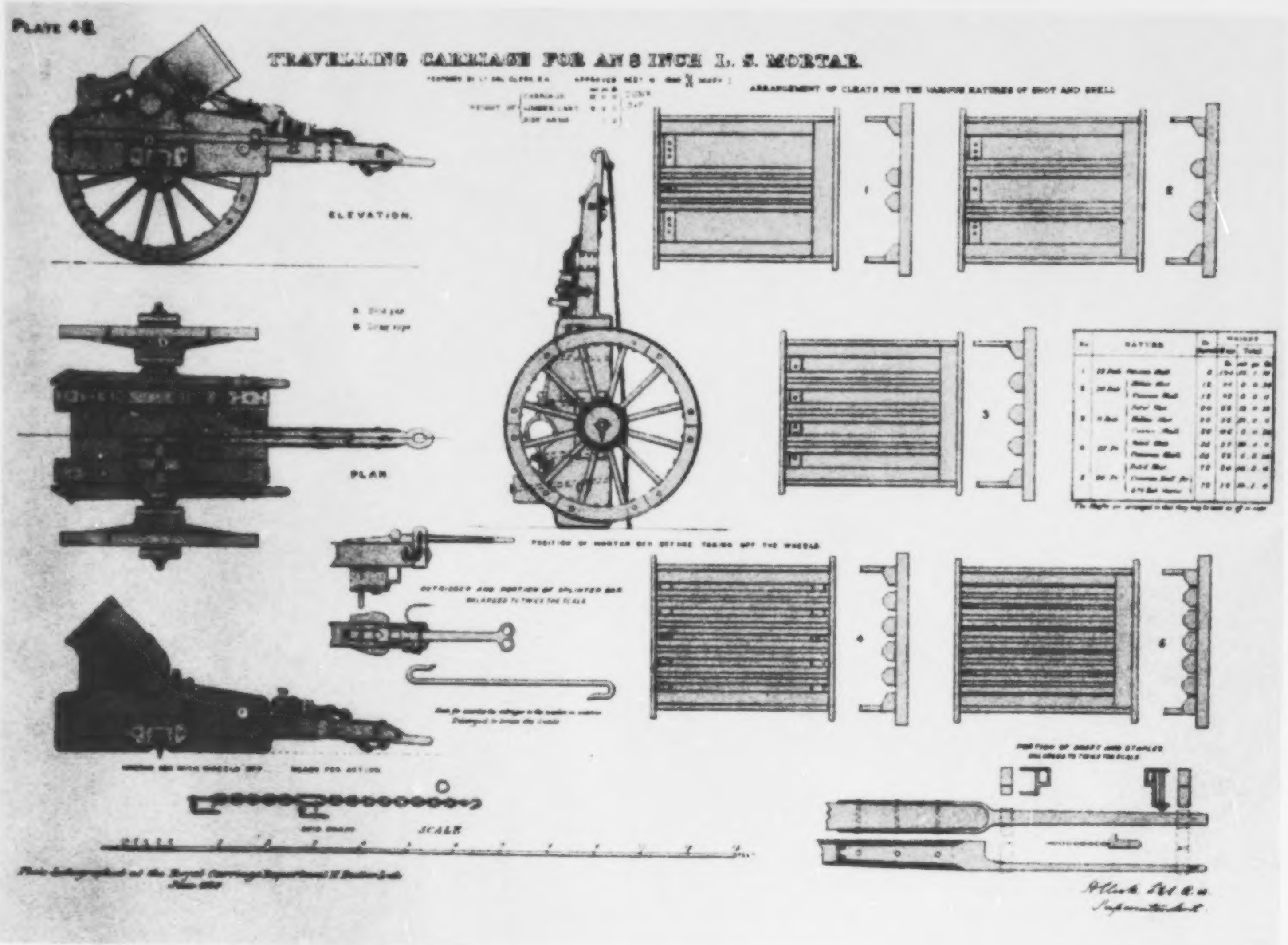


PLATE 48
TRAVELLING CARRIAGE FOR AN 8 INCH L. S. MORTAR.
ARRANGEMENT OF CLEATS FOR THE VARIOUS NATURES OF SHOT AND SHELL
ELEVATION.
PLAN
POSITION OF MORTAR BEFORE TAKING OFF THE WHEELS
1
2
3
4
5
SCALE

Figure 141. Travelling Carriage for an 8 inch L.S. Mortar. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 48, June 1869.)

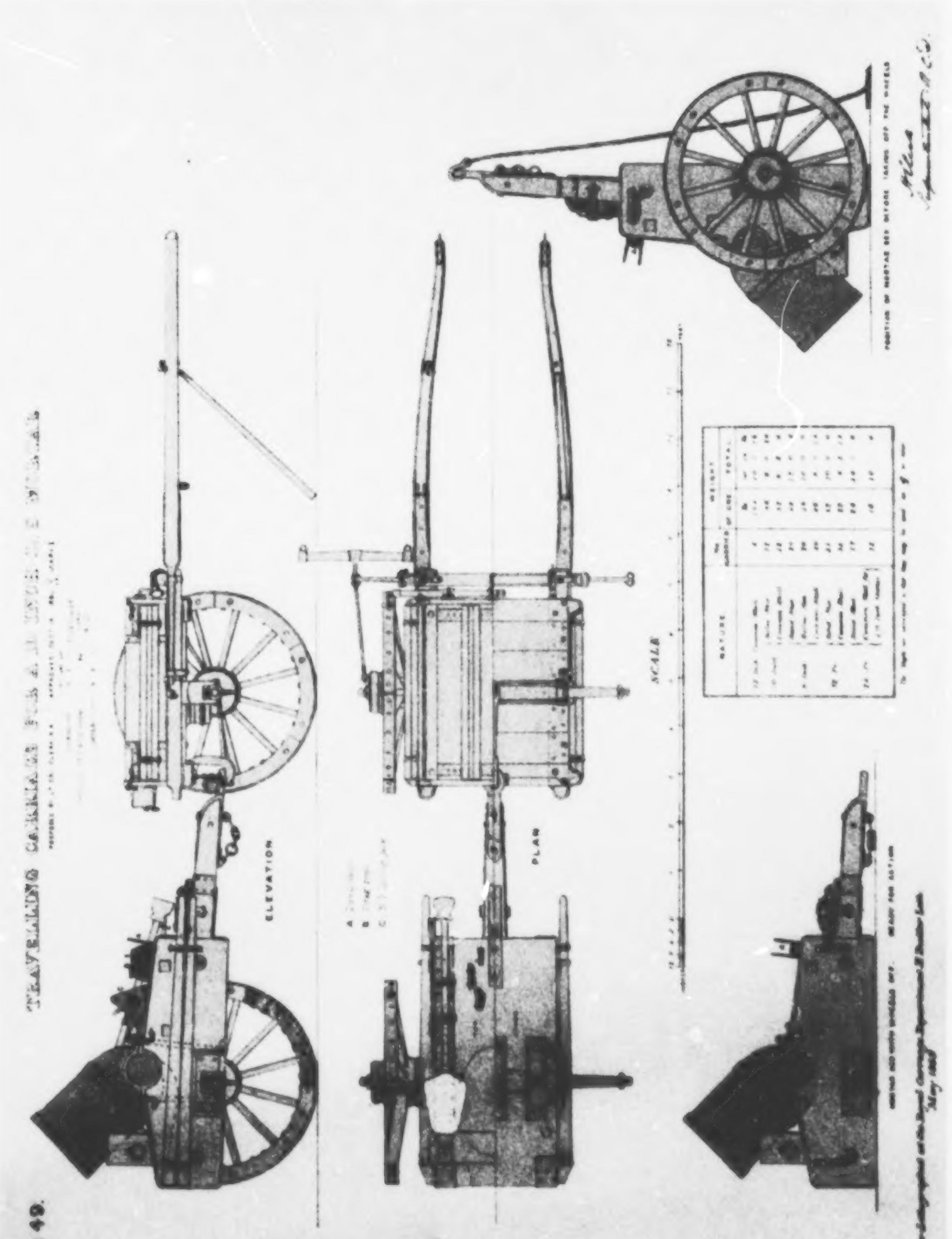


PLATE 49.
TRAVELLING CARRIAGE FOR A 10 INCH L.S. MORTAR
ELEVATION
PLAN
SCALE

Figure 142. Travelling Carriage for a 10 inch L.S. Mortar. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 49, May 1869.)

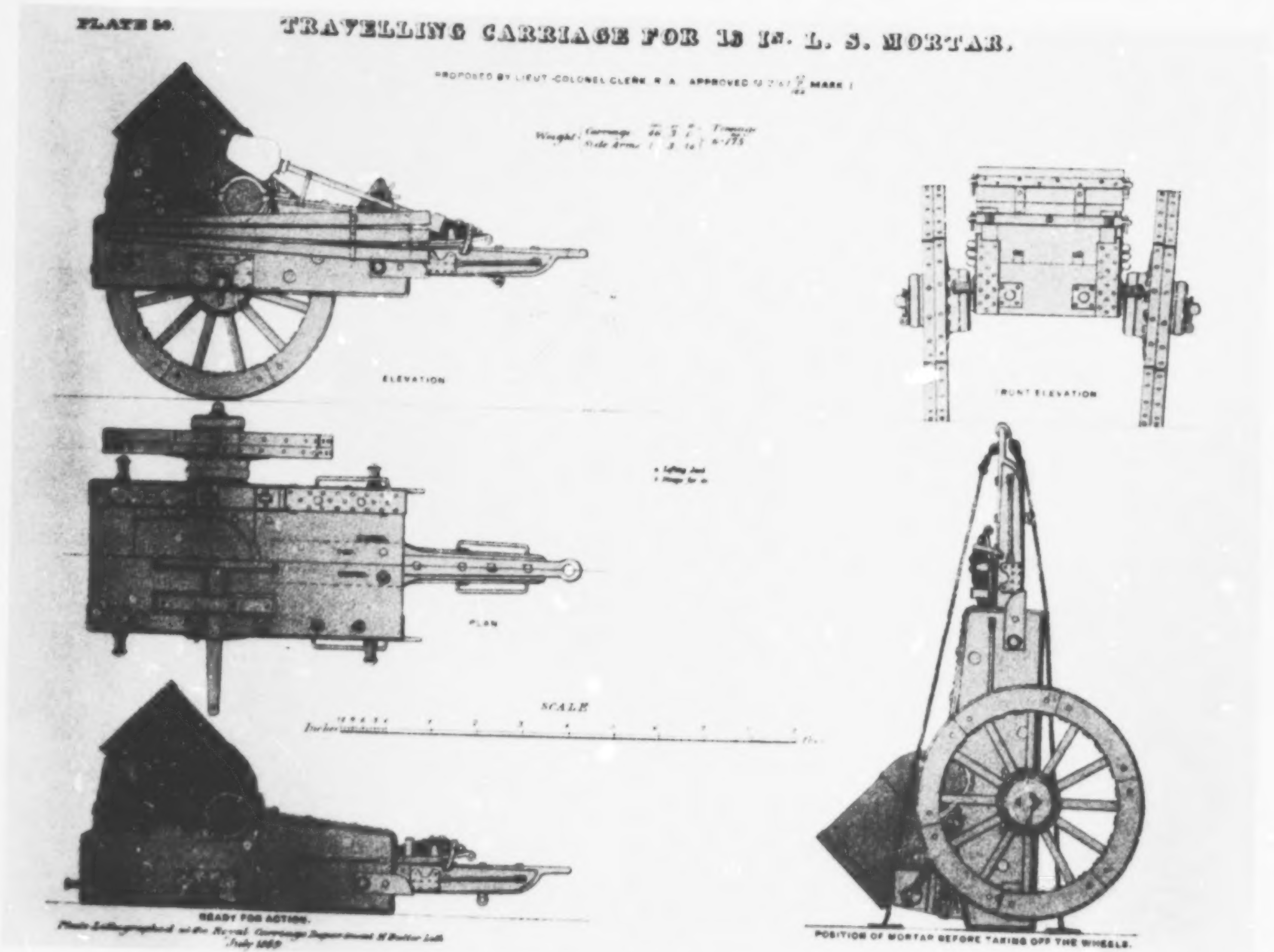


PLATE 50.
TRAVELLING CARRIAGE FOR 13 IN. L. S. MORTAR.
PROPOSED BY LIEUT.-COLONEL CLERK R. A. APPROVED MARK I
ELEVATION
FRONT ELEVATION
PLAN
SCALE
Inches
READY FOR ACTION.
POSITION OF MORTAR BEFORE TAKING OFF THE WHEELS.
July 1869

Figure 143. Travelling Carriage for a 13 In. L.S. Mortar. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 50, July 1869.

There is, however, a Coehorn mounted on its original bed at the Tower of London whose dimensions are slightly different:[70]

Length		Width		Height	
ft.	in.	ft.	in.	ft.	in.
1	11.8		11.8		8.3

This mortar bed was also equipped with a pair of lugs on each side which could be used for carrying or for running up.

The dimensions given thereafter, from the 1820s to the 1860s, were consistent.[71]

Calibre	Weight			Length		Width		Height	
in.	cwt.	qr.	lb.	ft.	in.	ft.	in.	ft.	in.
5 1/2	1	0	10	2	7	1	3		9
4 2/5		3	5*	2	5	1	3		8.5

*before 1840 only 3 qr.

Two drawings of a Royal bed appeared in the Aide-Mémoire in 1844 and again in 1853.[72] The iron work has changed slightly. Capsquares bolted on by two joint bolts and two eye bolts hold the mortar in place. A pair of rope handles are attached by rings to each side of the bed. A coin could be fitted under the mortar to give an elevation of 45 degrees; without it the elevation was 15 degrees. The dimensions of the bed are very similar to the above. The only difference in the two drawings was that the cavity of the 1853 drawing was longer than that of 1844 reflecting a change in mortar design (Fig. 144).

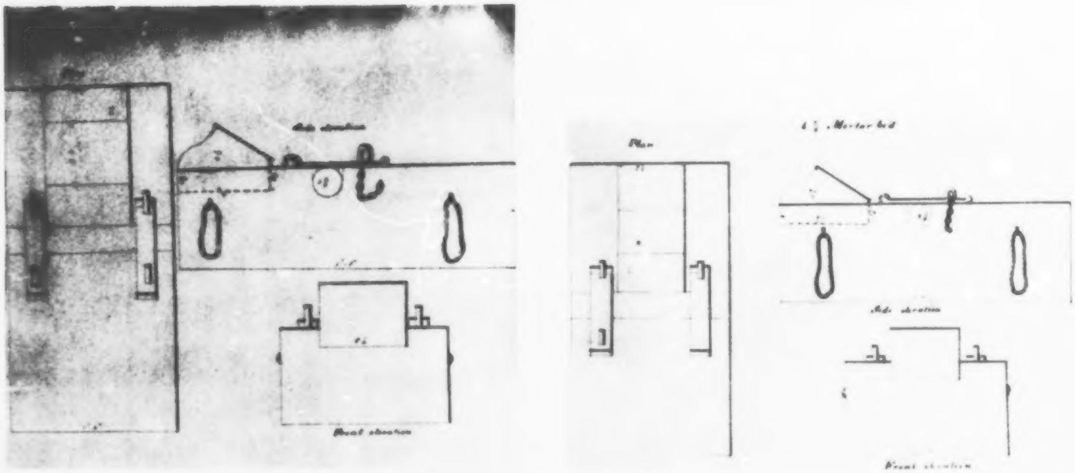


Figure 144. Beds for 5-1/2 and 4-2/5-inch Mortars, circa 1850. (The Royal Artillery Institution, Woolwich, U.K., Strange, "Drawings on Artillery.")

Travelling Carriages

As previously noted travelling carriages were designed to accompany an army into the field, either to act as siege weapons to bombard a city or fortress, or to give support to infantry and cavalry in battle. The designation of a carriage could be made in a number of ways – according to its function (field, position, or siege) or according to its design (double bracket or block trail). But regardless of designation a travelling carriage was made up of a pair of wheels, an axletree, and a body. The development of each of these elements is such that for analytical purposes they can be discussed separately (Fig. 145).

Wheels

A wheel was composed of a nave, 12 spokes, and six felloes. The nave was generally cylindrical but shaped and smaller in diameter towards its ends; it was pierced along its horizontal axis by a conoidal hole to take the axletree arm. The spokes were mortised into the nave. Muller wrote (and Adye agreed) that "The mortises of the spoke [sic] should be placed in the middle of the nave, but the workmen make them an inch nearer to the linch."[73] This statement is confusing in that Muller's own diagram showed the mortise holes nearer the axletree bed end of the nave, not the linch end, as did other diagrams into the 1840s. Later diagrams placed the spokes in the centre of the nave. The spokes radiated out to receive the

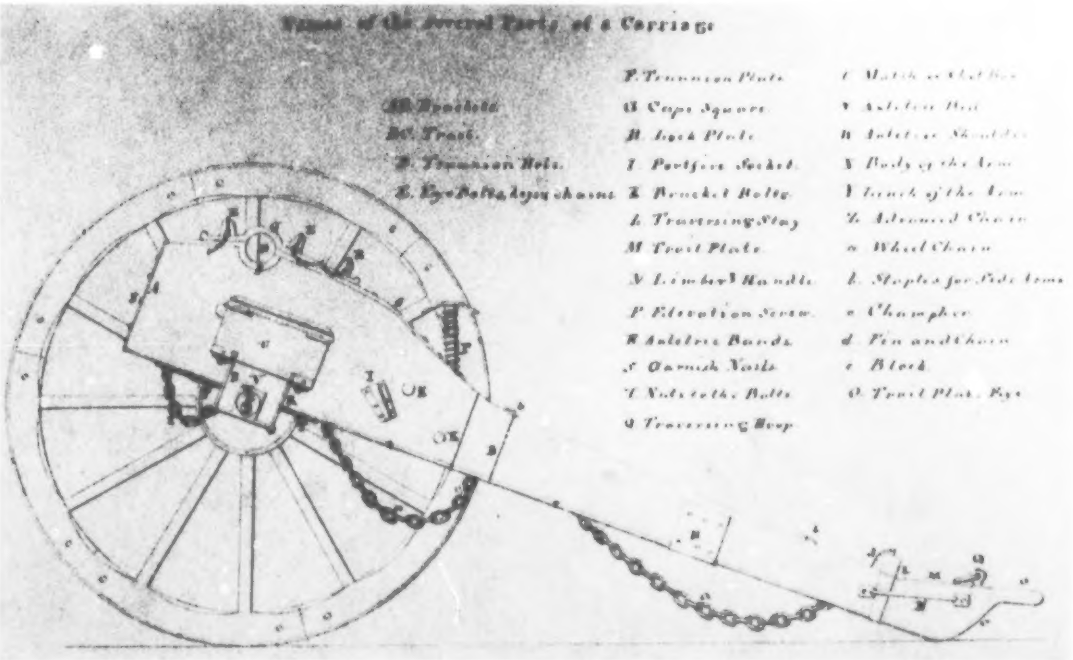

Carriage
A Brackets.
B Trail.
D Trunnion Hole.
E Eye Bolts
F Trunnion Plate
G Cape Square
H Lock Plate
I Portfire Socket
K Bracket Bolts
L Traversing Stay
M Trail Plate
N Limber Handle
P Elevation Screw
R Axletree Bands
S Garnish Nails
T Nuts to the Bolts
U Traversing Loop
V Axletree Bed
W Axletree Shoulder
X Body of the Arm
Y Linch of the Arm
Z Advanced Chain
a Wheel Chain
b Staples for Side Arms
c Champher
d Pin and Chain
e Block
O Trail Plate Eye

Figure 145. Names of the several Parts of a Carriage, circa 1825. (Royal Military College, Mould, p. 157.)

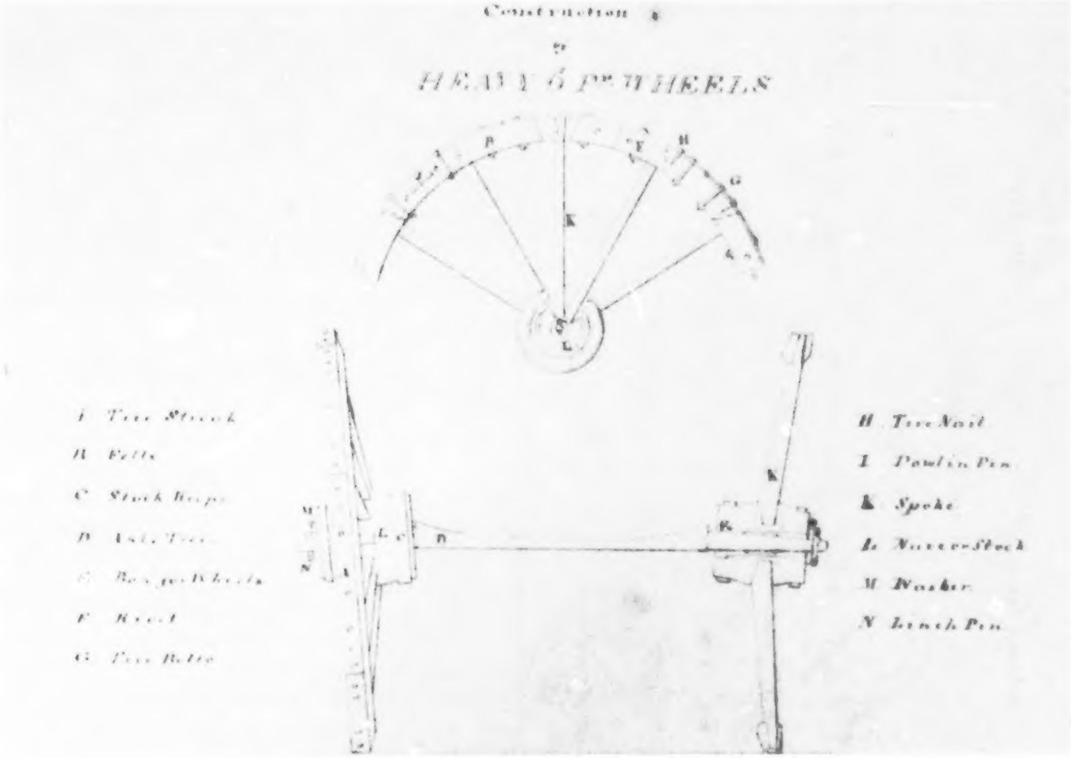

Construction of HEAVY 6 Pr WHEELS
A Tire Strake
B Felly
C Stock Hoops
D Axle Tree
E Box for Wheels
F Nail
G Tire Bolts
H Tire Nail
I Dowlin Pin
K Spoke
L Nave or Stock
M Washer
N Linch Pin

Figure 146. Construction of Heavy 6-Pr. Wheels, circa 1825. (Royal Military College, Mould, p. 167.)

felloes into which they were also mortised, the mortises extending entirely through them. The felloes, each of which received two spokes, were joined to each other by a wooden dowel inserted into their ends. When the felloes were in place, the spokes were trimmed flush, their tenons split, and wedges inserted into their ends to hold them in place. Although the parts of the wheel became more refined over 150 years, a refinement which can be seen in the accompanying illustrations, the essentials remained unchanged (Fig. 146).

The mortises were cut into the nave so that the spokes extended at an angle outward; this was known as dishing. Its purpose was to counteract stresses driving the nave outwards caused by the carriage turning or travelling over uneven ground that would have broken the spokes and destroyed the wheel had the spokes been inserted at right angles to the nave. Muller wrote that the spokes were inclined three inches in a wheel of a diameter of five feet. He went on:

> How they [the workmen] found out that this inclination renders the wheels more perfect is not easily known, those that I have conversed with know no more than that it was an old custom, which made me inquire farther into it, and I have found that it is grounded on true mechanical principles...[74]

Later sources in the mid-nineteenth century indicated that it was reduced somewhat to 2-1/2 inches in the 5-foot wheel.[75]

The nave was bound round with wrought iron hoops to prevent it from splitting while the spokes were being driven and afterwards when the wheel was in use. In Borgard's time four hoops were used, two on each end and two in the middle close to the mortise holes.[76] By mid-century only one of the middle hoops, that nearest the linch, was in place.[77] In the early 1790s Rudyerd still recorded three hoops, but sources in the 1820s showed that only two hoops were thought necessary.[78] It is not known precisely when the change occurred, perhaps in the 1790s or early 1800s with the development of the block trail carriage and the beginning of standardization of wheels and axletrees (see below). Whatever the case, the two hoops remained the practice from the 1820s onward.

The rim of the wheel, that is the six felloes joined by wooden dowels, was covered with a tire composed of six wrought iron streaks. Each streak was attached so that it was bisected by the joint of two felloes. According to Borgard's tables of 1719, the streaks varied in size with the calibre. The widest, those for the 24-pounder, were attached by 12 nails in a double row; the others, narrower, were attached by eight nails in a single row.[79] Muller, Adye, and Smith in the third quarter of the eighteenth century do not indicate that the 24-pounder streaks were double holed (they call for eight nails in all streaks for carriage wheels) but Rudyerd in 1792 showed the streak with 10 nail holes in a pattern of 2-1-2-2-1-2.[80] Limber streaks, since they fitted on smaller wheels, were shorter and were attached by six nails throughout the century. Again the date of change cannot be pinponted, but nails had given way partially to bolts by the 1820s -- four bolts and two nails (one nail next to each of the two spokes).[81] This seems to have remained the practice into the 1860s. Instead of streaks, a ring tire was adopted for the light 3-pounder, by 1839 at least, and probably for the 4-2/5 inch howitzer, and their limbers.[82] Dowledges were flat pieces of wrought iron fitted into the outer sides of the felloes, straddling the joints, and attached with rivets. In 1719 Borgard indicated that those of the wheels of the 24- and 12-pounder carriages were attached by four rivets each while those of the other carriages and limbers by two rivets each.[83] Muller, Adye, and Smith say that dowledges of travelling carriages generally were attached by four rivets,[84] Rudyerd showed four rivets for the dowledges of 24-pounder and the 8-inch howitzer carriage, but two rivets for those of the 24-pounder limber and the light 6-pounder carriage. Dowledges were not shown on the wheel of the light 6-pounder limber, but this could have been an oversight.[85] According to Hughes, in his study, dowledges had vanished by about 1800; certainly drawings in the 1820s failed to show them.[86] They were replaced by rivets, driven through the felloes near the end of the dowel holes, whose purpose was to prevent the felloes from splitting. (They appear not to have been used in the wheels for the light 3-pounder, presumably for the 4-2/5-inch howitzer, and for their limbers.)

To prevent the wearing away of the axletree arm hole through the nave, the hole was lined with metal nave-boxes. In 1779, Smith wrote that these "...were formerly made of brass; but experience has shown that those of cast-iron cause less friction, and are much cheaper."[87] However, the tables prepared by Borgard and the writings of Muller and Adye before 1779 all included pipe-boxes under the heading "iron work" and made no reference to brass.[88] Further confusing was Adye's statement in 1813:

> The wheels for the Guns, Limbers, and Ammunition Carriages, have brass boxes. Those for Waggons, Carts, &c. have iron boxes.[89]

In the mid-1820s they were said to be of gun metal,[90] but sources for 1841 onward referred to them as made of iron.[91] It is not clear precisely what Smith meant by "formerly" but probably brass or gun-metal boxes were used in the first quarter or more of the nineteenth century, at least for gun carriages, limbers, and ammunition carriages.

In the eighteenth century the nave box was of two parts, one part inserted at each end of the arm hole, prevented from turning by a feather and held in place by metal pins. Between them there was a slight hollow to hold grease.[92] In 1825, the description of the gun metal nave box indicted that it was in one piece, extending completely through the nave; it was hollowed out in the centre for the double purpose of holding grease and allowing the axletree arm to bear only on about 3 inches at each end.[93] Descriptions in the 1840s and later indicated that wedges were driven in around each end, their purpose being not only to secure the nave box firmly but to ensure that it was exactly in the centre of the nave.[94] The change from gun metal to cast iron did not change the design of the box.

Even in the eighteenth century, there was a tendency toward the standardization of wheels to allow for much wider substitution if wheels were damaged or destroyed in action. This tendency was probably accentuated in the 1790s when the block trail carriage and new limber were developed for Horse Artillery and a wheel with a diameter of 5 feet both for the carriages and limbers came into use. This development was quite clearly reflected in the tables of wheel dimensions published by Adye in 1801 and 1813, especially for those of the brass field pieces (Appendix HH).[95] The design of wheels for siege artillery or guns of position seemed to change more slowly, but certainly by the 1820s a system of dimensions was in place which remained reasonably constant into the 1850s. A comparison of tables of dimensions from Mould's notebook of 1825 and from Spearman's two editions of the British Gunner in 1828 and 1844 show that there was little if any change (Appendix II).[96] It should be noted that in 1844 Spearman added the wheels of the 18-pounder gun and the 8-inch howitzer and of their limbers to the category of field carriages; these were clearly intended for guns of position. A reasonable assumption would be that they would be the same as the wheels for the siege equipment, but while the limber wheels of both classes seem to be the same (a difference of 9 pounds), the carriage wheels for the pieces of position were heavier. As well Spearman included a 12-pounder gun with 18-pounder and 8-inch howitzer siege weapons, a weapon which seems too light for battering purposes. Perhaps he has transposed the position and siege weapons. Other than this relatively minor problem, these tables give a reasonably complete picture of wheels into the 1850s. By the 1860s the final classification of wheels for smooth-bore gun carriages had come into effect, with the addition of heavier weapons to the siege train and the development of travelling carriages for the 8-, 10-, and 13-inch iron mortars (Appendix JJ).[97]

Axletrees

Throughout the eighteenth century an axletree was a substantial construction of wood reinforced by an iron bar set into its underside and bound round by a number of iron hoops. It was composed of a central rectangular bed from which two arms extended. The arms were turned to take the wheel, but their shape was somewhat unusual. Viewed from above the arm tapered evenly away from the bed towards the linch; viewed from the side the bottom was level while the top sloped down from the shoulder of the bed to the linch. When the wheel was in place this slope would tilt the wheel so that, as it turned, the dish of the wheel was counteracted and the working spoke, that is the one directly beneath the axletree arm, was more or less vertical when the wheels were level.[98]

An axletree bar was set into the complete length of the underside of the axletree. It was held in position by a bolt passing down through the centre of the bed and keyed into place. Borgard's table of 1719 indicated that the axletree of the limber was similarly equipped and Adye in 1766 and Muller wrote that the iron work for the limber axletree was the same as that for the carriage axletree; however, Rudyerd's drawings in the early 1790s failed to show a bar among the iron work for the limber.[99] It is not clear why a bar would no longer be thought necessary for the limber axletree.

Also holding the bar in place and keeping the axletree from splitting was a number of bands or hoops. All sources agree that there was a linch hoop around the extremity of the arm. They also indicate that there was another arm hoop – Borgard described it as "Hoop in the middle of the arm," Rudyerd as "Middle arm hoop," and Landmann, in a drawing, showed it circling the middle of the arm.[100] This would mean that when the wheel was in place, this hoop would be inside the nave where there was a hollow for grease. Borgard did not indicate any other hoops, but later sources described two body bands around the shoulders of the axletree bed.[101]

To protect the arm where it bore upon the nave boxes, iron clouts were nailed onto the underside of the axletree arm at the linch and at the shoulder of the bed. An inch or so from the end of the arm a hole was drilled to take the linch pin which along with a washer held the wheel in place.[102]

The last piece of iron work to be discussed provides some problems. According to Smith, a hurter was

> a flatted iron fixed against the body of an axle-tree, with straps to take off the friction of the naves of wheels against the body.[103]

Although its general purpose was apparent, it is not clear precisely what was meant by "straps" nor precisely how the hurter was attached. Rudyerd drew two sorts of hurters, one for the carriage and one for the limbers. The limber hurter was like a washer but with a rectangular flap attached through which there were three holes for nails. It could be nailed through this flap to the shoulder of the bed and edge of the bolster immediately above. The carriage hurter, without the flap, had four holes in it equidistant from each other. Although these evidently were for nails, given the shape of the bed shoulder, only one of the holes could actually be used.[104]

Sometime before 1800, precisely when is uncertain, the ordnance began a transition to iron axletrees for field guns. The wooden axletree bed remained, into which a wrought iron axletree was set, bolted and bound in place. In 1801 Adye noted in his Pocket Gunner that "Most of the field carriages are now made with iron axletrees..."; he then gave dimensions for the following:[105]

Iron Axletrees	Diameter of Arm		Length of Arm		
	shoulder	point	Nave part	Washer part	To Linch pin
6-pr. light	2 3/4	1 3/4	13	5/8	13 5/8
3-pr. heavy					
5-1/2 in. howitzer					
12-pr. light & limber	3 1/4	2 1/4	16	3/4	16 3/4
12-pr. medium	3 1/2	2 1/2	16	3/4	16 3/4
12-pr. medium limber	2 3/4	2	13	5/8	13 5/8

By 1813 the transition was complete for field carriages.

> All the field carriages are now made with iron axletrees, which are more durable than wood; their diameters being less, the friction is thereby decreased, and they require less grease. There are but two sorts used, heavy and light.[106]

Unfortunately no dimensions were given.

The use of iron axletrees also extended to siege carriages. In 1820 a committee of artillery officers reported:

> ...the 24 Pounder Battering Gun is the only one the Carriage of which has a Wooden Axletree, they are persuaded that an Iron one can be adopted to it with the greatest advantage, experience having shewn that it is the part most apt to give way, both in Firing and Travelling. – The experience of the 18 Pounder Battering Ordnance moving in Spain and France during the late Campaigns, fully authorizes this conclusion; as well as the late experiments with the 10 Inch Iron Howitzer.[107]

The first set of more or less complete dimensions of iron axletrees that has been found was in a student's notebook of 1825. Also included were diagrams and instructions for drawing the axletree arms of light and heavy 6-pounders, 18-pounders, and 24-pounders. The accompanying table indicated that there were two other axletrees for 3-pounder, 1-pounder, and 4-2/5-inch howitzer.[108]

A comparison of this set of dimensions with similar tables appearing in two editions of Spearman's The British Gunner in 1828 and 1844 indicates that there was little, if any, change in the 1830s and 1840s.[109] What differences there were are minor, and the important dimensions of the axletree arm remained unchanged. The only major change by 1844 seems to have been the adoption of a lighter axletree for the 8-inch iron howitzer, the one that was used for the limbers of all iron ordnance. As well, the table of 1844 did not include the dimensions of axletrees for mountain guns and the 5-1/2-inch howitzer which had been included in 1828. Use of those diagrams and tables then should give us a good picture of axletree construction into the 1850s (Fig. 147).

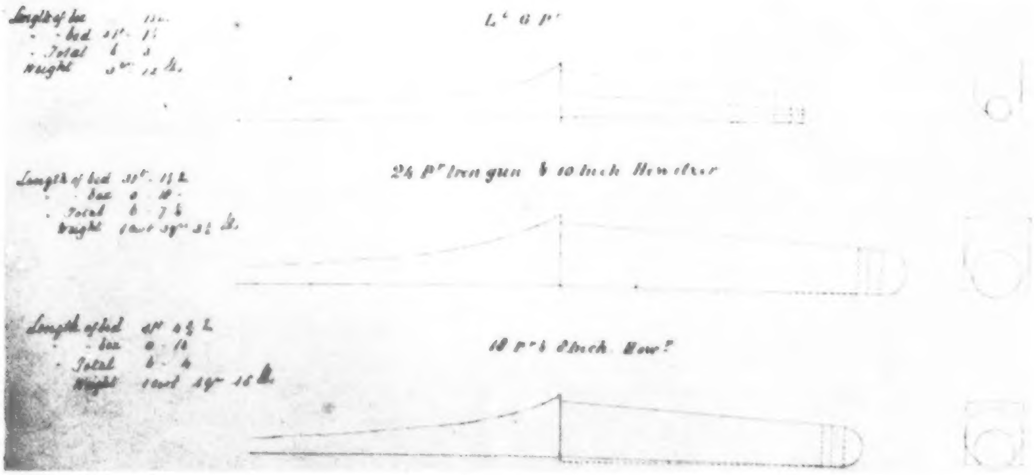


Figure 147. Axletree Arms, circa 1850. (The Royal Artillery Institution, Woolwich, U.K., Strange, "Drawings on Artillery.")

The tendency and indeed purpose of this development, which of course went hand in hand with the design of the nave or pipe box, was to reduce the number of types of axletrees in use and to allow the interchanging of wheels between the carriages and limbers of pieces of artillery that were used together. This was made possible by the standardization of the axletree arms and the pipe or nave boxes and the adoption in most cases of a wheel of a diameter of 5 feet. This process reached its culmination in the 1860s with the designation of four classes of axletrees, the last of which, for naval service, need not concern us at all (Appendix UU).[110]

We do not have anything like a complete description of the manufacture of iron axletrees until the 1860s, but presumably the process had changed only in detail and in the sophistication of the machinery used. Fitzhugh, writing in his notebook in 1845, noted:

> Formerly there were two iron axletree arms let into the axletree bed but now a different system has been adopted. The two axletree arms are joined and form one piece.[111]

On the face of it, using two separate axletree arms seems unlikely as both awkward and weak. It is possible that some system such as Fitzhugh suggested was practiced early, but clearly a single axletree was in use at least by the 1840s and probably well before.

Wrought iron was heated and hammered into the approximate form of one-half of the axletree and then finished on a lathe. Then the two halves were welded together. By the 1860s, to prevent the arm being worn away by the friction between it and the pipe box, a piece of steel was inserted into a slit cut in the underside of the arm and heated and hammered until it was incorporated with the arm. It is not known when this process of steeling was initiated.

The axletree arm was designed with a "hollow" and a "lead." The purpose of the hollow, which was given by bending the arm downwards slightly, was to counteract the effect of the dish of the wheel by bringing the working spoke, which was immediately under the arm into a vertical position when the wheels were level; otherwise this spoke would be subject to transverse stress. The hollow and dish had a tendency to cause the wheel to rotate slightly away from the direction in which the wheel was turning. To counteract this, lead was given to the arm by bending it forward slightly. The hollow was 3/8 inch and the lead was 1/8 inch for a wheel of a diameter of 5 feet.[112]

Bodies

Until the introduction of the block trail carriage in the 1790s, the basic construction of the bodies of travelling carriages, whether for heavy or light (field) guns, remained essentially unchanged during the eighteenth century (Fig. 148). The body was composed of two side pieces or brackets which were cut from single planks and joined together by transoms and bolts. The axletree bed was bolted to the fore part of the body just behind the trunnion holes. When the wheels were put on, the carriage rested on the ground at three points, at each of the wheels and at the trail of the body which was rounded to facilitate recoil.

In the case of heavy travelling carriages, four transoms were fitted into the brackets to join them together (for dimensions at various times see Appendices VV and WW). The fore or breast transom was housed vertically just in front of the trunnion holes, parallel to the head of the bracket. At about the mid-point the middle transom was set into the brackets and about two calibres in front of it the bed transom was fitted. The bed on which the quoin would rest to support the breech of the gun was attached to and stretched between these two transoms; when the trail

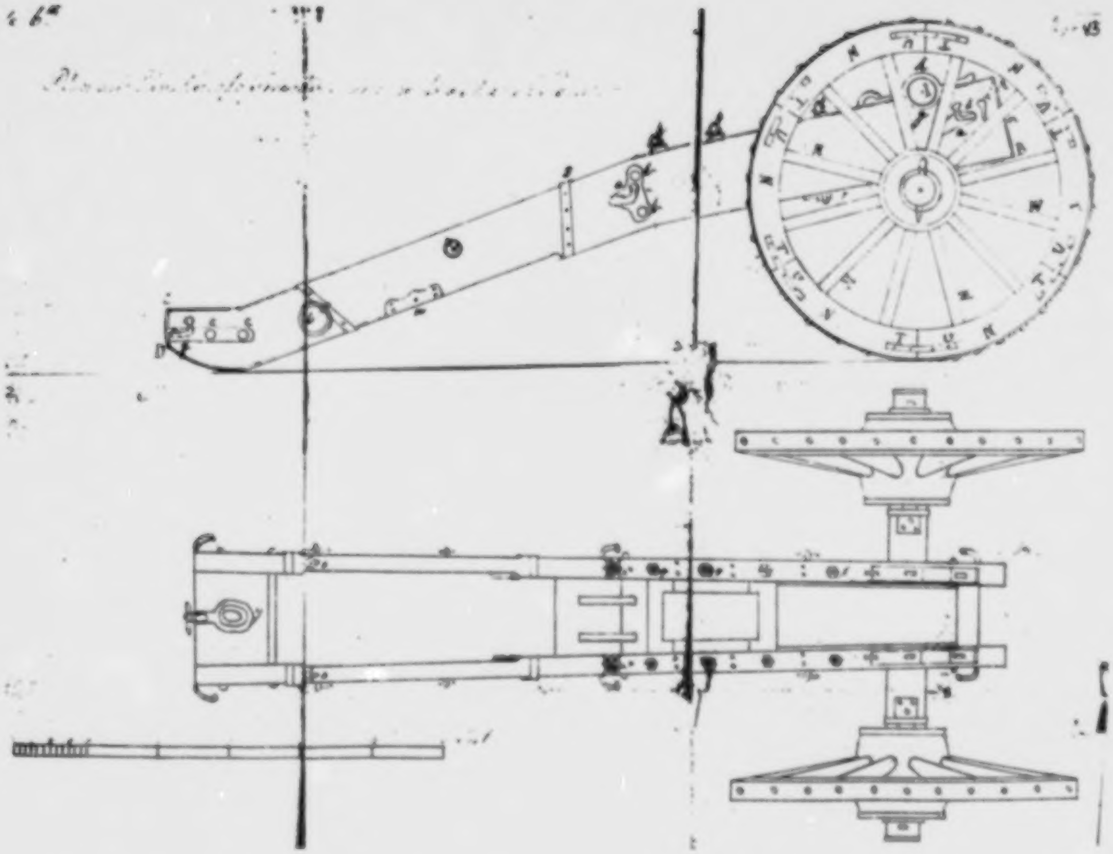


Figure 148. Plan and Elevation of a Travelling Carriage for a Heavy 6 Pounder. (The Royal Artillery Institution, Woolwich, U.K. Adye (1766), Plate 6.)

was resting on the ground, the bed was level. The rear or trail transom, which was pierced in the centre to take the pintle of the limber, was tenoned into the trail parallel to the ground. The brackets were bound together by five bolts — one just behind the breast transom, two (one above the other) just behind the middle transom, and one in front of and one through the trail transom. These bolts also held in place three transom plates with hooks on each bracket of the carriage; the ends of the bolts were riveted against the plates.

The edges of the brackets were protected by a number of wrought iron plates. The breast plate was nailed onto the front edge of the bracket and folded over onto the top and bottom edges. On the top it adjoined the trunnion plate, which stretched back to cover the bracket to the rear of the trunnion hole. The latter was held in place by an eye bolt in front of the trunnion hole and by an eye bolt, joint bolt, and garish bolt behind it. These bolts penetrated through the brackets, both eye bolts emerging in front of the axle tree and the joint and garnish bolts behind. The axletree band which bound the axletree to the bracket was fitted over the bolt ends and keys inserted to secure the bolts and bed. (In the 1790s, Rudyerd did not show a garnish bolt.) The joint bolt was attached by a rivet to the capsquare that pivoted to fit over the eye bolts to secure the trunnion when a gun was mounted on the carriage.

A spring key, attached by a chain and staple to the bracket, was inserted into each eye bolt to secure the capsquare. Immediately behind the trunnion plate a garnish plate extended back just to the rear of the middle transom; it was attached by a number of small nails, three garnish nails, and a rose-headed nail driven through the rose (a decorative element) which terminated the plate. The trail plate was nailed round the trail of the bracket; it too terminated on the upper edge in a rose through which a rose-headed nail was driven. An upper and a lower pintle plate were nailed on top of and beneath the trial transom; a loop, through which a handspike was inserted for traversing, was riveted through the plate at the very end of the transom. Iron straps were nailed round the bracket near the points where it was reduced in thickness between the middle and rear transoms. An eye bolt, to which a draught ring was attached, was riveted through the rearmost strap. Immediately in front of it a locking plate was nailed to protect the bracket from the limber wheel when the carriage was turned sharply. Finally, two lashing rings, to which side arms could be secured, were riveted to each bracket.[113]

Field carriages for the smaller guns were proportionately lighter and shorter in construction. The only difference in the woodwork was the lack of a bed transom because, rather than quoins, screws were used to elevate these guns. Consequently, the centre transom, which was about two calibres broad and one thick, was placed in the middle of the brackets so that its centre was immediately underneath the neck of the cascable. The housing for the screw was fixed therein.[114]

According to Muller, the light carriages had two lockers or boxes on each side of the carriage, one sliding on top of the other, attached in a manner that is not precisely clear from his description:

> on each side of these carriages is a locker or box of two feet long, its upper surface even with, or about an inch above the upper part of the axle-tree, extending from thence toward the trail; and its depth is equal to the height of the axle-tree. These lockers serve to hold shot upon a march, and are covered each by another box that slides on, and is fastened with a bolt, in which cartridges are lodged, to be ready for firing at any time, without having recourse to the ammunition carts.[115]

In the next paragraph he noted that the garnish bolt "supports the fore part of the locker."

Muller's description of the iron work of a field carriage indicated that it was lighter and that there were some differences as compared to that of a heavy travelling carriage. There were no garnish nails, although they had been included in error upon Plate XI. He then explained:

> The eye bolt next to the joint bolt passes through the axle-tree band behind, and not before as in other carriages; the fore part of this band is only fastened by the fore eye bolt.[116]

But in the diagram of the cheek of a field piece, Plate XI, he showed the arrangement whereby both eye bolts passed to the front of the axletree. Also, he drew only one bracket bolt at the centre and the trail, but he indicated in the text that the practice was to have two at each point, which he argued was superfluous. He also commented:

> The draught hooks are placed to the breast transom plates, instead of fixing them to the axletree, as practiced; because the horses draw with more strength when the hooks are nearly breast high.[117]

This seems to indicate that existing field carriages had hooks attached to the axletree, presumably the bed. He suggested that

> instead of making hooks to the trail transom plates, there are

> substituted nails about four inches long, which we imagine are much more convenient than the former.[118]

It seems clear that hooks were current, but he felt that nails were more convenient for lifting the trail, but surely not for attaching drag ropes to retreat the gun. Finally he wrote:

> The washers have also hooks, to which are fastened the ropes by which the gunner draw the gun along.[119]

Presumably this was actual usage. The mixing of actual practice and his suggestions makes this a confusing paragraph.

Dimensions of the field carriages for 3-pounders were not given by Muller, Adye, and Smith; it may well have been that the light 3-pounder of 3-1/2 feet was usually mounted on a galloper carriage, which, although developed for a 1-pounder, was said to be suitable for a 3-pounder. Whatever may have been the practice in the 1760s, it is clear that by the mid-1770s two conventional double bracket field carriages had been developed by James Pattison and William Congreve for new light 3-pounders of 3 feet. Adrian Caruana, in one of his many articles on eighteenth century artillery, has outlined the history of these guns and their carriages.[121] Pattison's carriage, which Caruana argues was known as the grasshopper, was a double bracket design with certain unusual features allowing it to be moved over rough ground or through woodlands where there were no roads but only trails. It could be taken apart and carried on horseback or it could be carried by eight men using crooked handspikes inserted into metal holders attached to the outsides of the brackets at front and rear. There were no side boxes or lockers, but some ammunition and small stores were carried in a large box attached between the brackets to the rear of the gun. Although there were no draught hooks and the bolts are not indicated in the diagrams reproduced by Caruana, generally the iron work shown was similar to, but undoubtedly lighter than, that of the conventional travelling carriage.

The second carriage, which Caruana argues was known as the Butterfly, was developed by William Congreve to carry the light infantry, or Lord Townshend's 3-pounder of 3 feet. It also was a double bracket design, but slighty shorter than Pattison's carriage; it was the same width between the brackets in front but did not widen so much in the rear as the Grasshopper. Congreve's contribution to design may have been determining the manner in which the ammunition, small stores, and side arms were stowed on the carriage. There were two side boxes resting in part on the axletree bed, a box between the brackets to the rear of the gun (not as deep as that of Pattison), and a small locker underneath the gun. The carriage could be pulled by a limber or, if desired, it could be hooked up directly to the limber shafts and used as a galloper. All the bolts are not shown in the diagrams reproduced by Caruana, but its iron work also seems to have been conventional.

In 1776 the older pattern carriage for the light 6-pounder was modified by order of Lord Townshend, Master General of the Ordnance, and a new carriage designed by William Congreve came into service. The older carriage had a number of shortcomings. Its wheels of 4 feet diameter were too small to allow for efficient draught especially on badly rutted roads or over rough country. The brackets were too short for the side arms to be conveniently carried on them during action and they were often lost when the gun advanced or retreated. The elevating screw did not allow for sufficient elevation or depression to support infantry properly if the enemy were nearby but on a height or in a gully. Moreover, because the box of the elevating screw was fixed in the centre of the transom it often jammed when the gun reached the limit of its elevation or depression, and the levers of the box were sometimes wrenched off in trying to free it. Finally, the breast drag hooks were found to get caught in the mens' clothing. As well the hooks were too weak for attaching ropes to pull the carriage up difficult terrain.

Congreve's modifications also dealt with these problems and others. The diameter of the wheels was increased to 4-1/2 feet to improve the draught. The cheeks were lengthened from 94 to about 104 inches. The elevating screw was modified so that its box moved back and forth in an oval affixed in the transom. It allowed elevations through 16-1/2 degrees and no longer jammed. The levers of the box were underneath the transom out of harms way. The breast hooks were replaced with eye bolts. These were either fixed to hoops driven round the axletree bed or they were driven through the bed; both descriptions were given. Eye bolts did not interfere with the mens' clothes and they were stronger than the hooks.

Congreve made other changes as well. He cut away the upper surface of the cheek from the trunnion hole to the breast so that it was parallel to the horizon. This allowed sighting to be taken along both sides of the gun and over the top. The side lockers were replaced by a locker underneath the gun. Boards were laid on top of the axletree bed extending back over the locker bar to support the side boxes. A set of drag ropes and a set of men's harness could be coiled on hooks underneath the carriage where the lockers had been. The drag ropes were to be made of tarred rope rather than white rope to preserve them better from damp. They were equipped with a hook on one end and a loop on the other rather than loops on both ends. Finally, newly designed fork levers, replacing the common handspikes, were to be carried between the brackets.[122] The new carriage with its limber was heavier than the old pattern, but it was felt to be a more efficient vehicle.

A slightly different field carriage, the galloper, should be mentioned at this point. It was a gun carriage equipped with shafts, thereby allowing it to be pulled without a limber. Two small brackets, to support the gun, were mounted between the wheels, resting on the axletree bed and a cross bar. As well, an ammunition box or locker was attached on each side. It was designed for 1-1/2-pounders, but according to Muller and Adye it might also be used for 3- and 6-pounder guns.[123]

It seems to have dated from at least the 1720s. In his notebook, James included a table entitled "Dimensions and Draughts of Galloping Carriages for Field Service, according to my own Projection and approved by the Honble. Board of Ordnance June 3rd. 1725." He set up the table to include 6-, 3-, 1-1/2-pounders, howitzer, and amusette, but unfortunately he never completed it, nor did he make the drawing.[124] Some kind of a galloper may have existed previously, for there was also a table of wheel dimensions according to the Regulation of 1722 which gave dimensions for the hind, i.e. carriage, wheel of a 1-1/2-pounder but not for the fore, i.e. limber, wheel; this seems to imply a vehicle without a limber.[125] Whatever the case Muller and Adye supplied a table of dimensions and drawings after mid-century (Appendix PP; Fig. 149).[126]

It is not known how extensively this carriage was used, but it will be recalled that Congreve's carriage for Lord Townshend's light 3-pounder in the 1770s could be fitted up as a galloper by attaching the "mantlet limber" shafts directly to the trail of the carriage (see above). Interestingly, this form of draught returned to service by the mid-1840s for the mountain carriages of the light 3-pounder and 4-2/5-inch howitzer (Fig. 150).[127]

The Block Trail Carriage

The next important development in carriage design was the introduction of the block trail, firstly for horse artillery, shortly for all field guns, and eventually for siege guns and guns of position. Instead of two long brackets joined together by

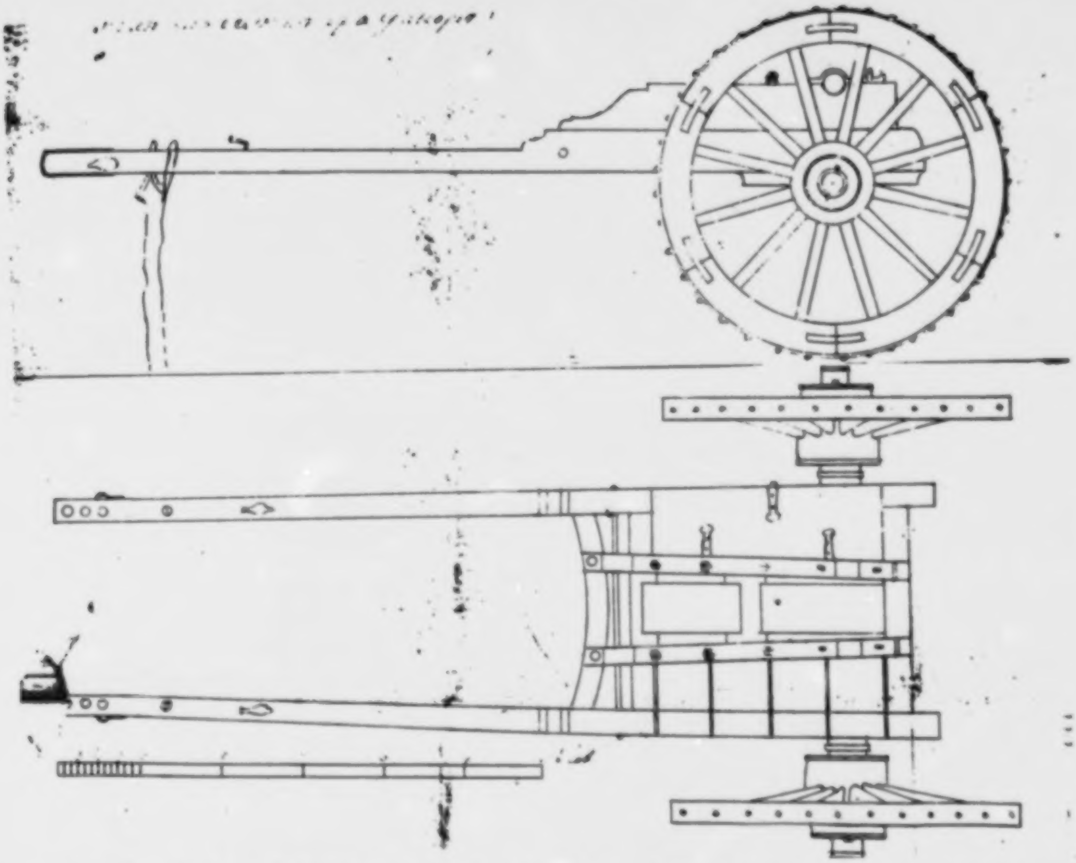


Figure 149. Plan and Elevation of a Galloper. (The Royal Artillery Institution, Woolwich, U.K., Adye (1766), Plate 8.)

transoms, this new pattern carriage consisted of a solid central shaft of wood to which two small brackets were fitted and bolted at the front to support the trunnions of the gun. The shaft tapered toward the trail which was turned up and shaped in much the same way as the double bracket carriage.

The new design had a number of advantages over the older pattern. The centre of gravity of the latter was too far to the rear necessitating heavy work for two men with handspikes to traverse the gun or to lay it under the direction of the commanding N.C.O. With the new design, the trail could be picked up by one man using a crooked handspike; moreover, this same man could lay the gun as well. The narrowness of the block trail allowed a greater amount of lock to be given the limber, thereby allowing the whole carriage to be reversed almost on its own ground.[128]

As early as 1779 or before, Desaguliers had designed a carriage for a heavy 3-pounder suitable for use with cavalry which, according to Congreve, was based on some field carriages captured on the island of Martinique in 1761. Drawings of manoeuvres which Desaguliers asked Congreve to prepare indicated that the carriage was a block trail. In 1788, when the Duke of Richmond, Master-General of the Ordnance, ordered Congreve to design carriages for field pieces and ammunition wagons, Congreve had recourse to Desaguliers' design. Richmond specifically ordered that

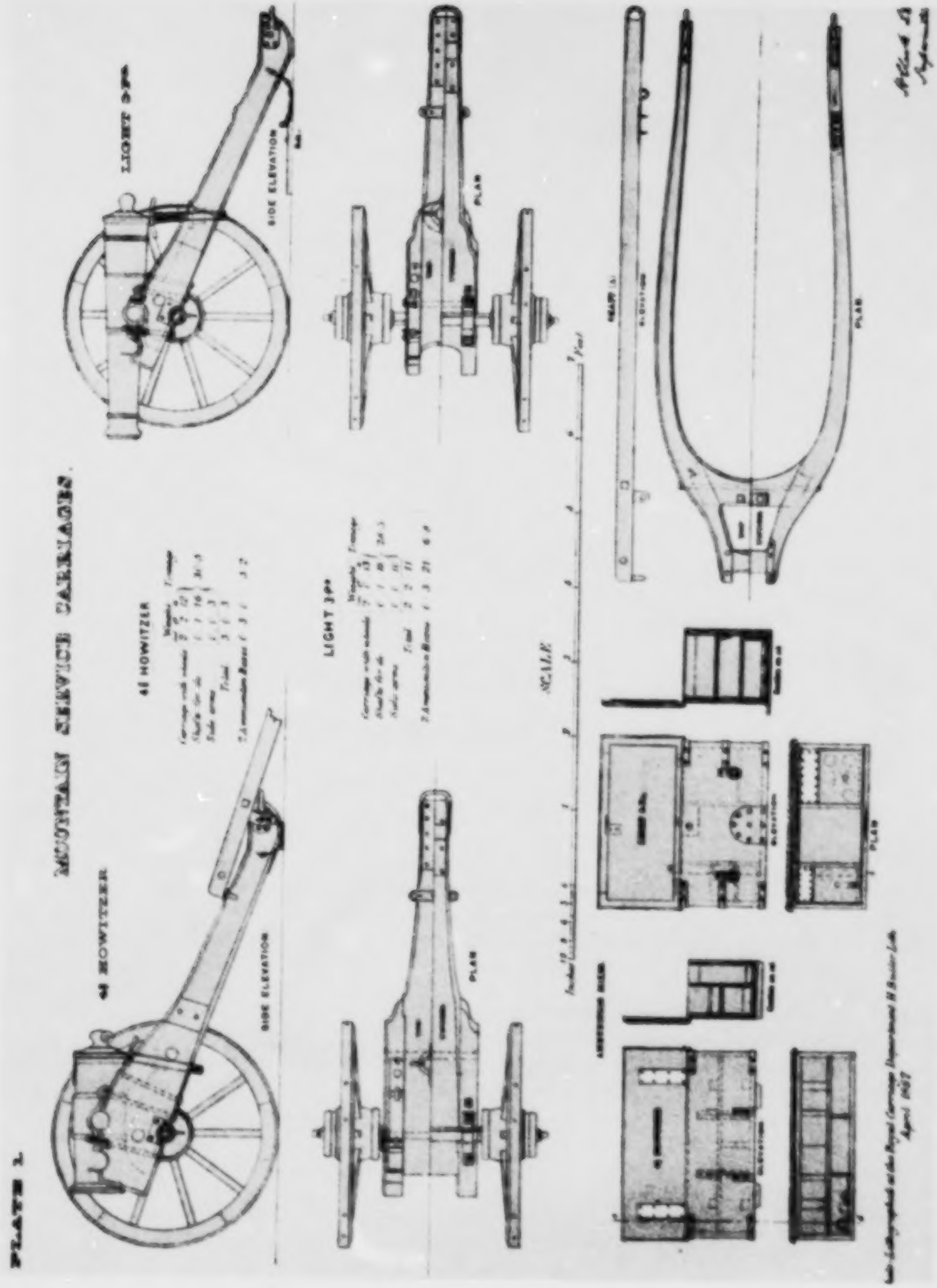


PLATE 1
MOUNTAIN SERVICE CARRIAGES
4⅖ HOWITZER
LIGHT 3-Pr
SIDE ELEVATION
PLAN
SCALE
ELEVATION

Figure 150. Mountain Service Carriages (4 2/5 inch Howitzer and Light 3-Pr.) (The Royal Artillery Institution, U.K., Royal Carriage Department, Plate 1, April 1867.)

> the Wheels & Axletrees of the Gun Carriage & its Limber [were to be] of the same Diameter & strength as those of the Ammn. Waggons, & that the Fore Wheels and Axletrees of each Carriage should be of the same height & strength as the hind ones.[129]

To meet these requirements, that is to enable high wheels to be used with limbers, Congreve saw that only Desaguliers' design would allow the carriages to turn as short as the older pattern. In 1779, by his own testimony, Congreve had made some "trifling additions" to the design and, in 1788, had felt it was only necessary to strengthen the block or shaft to prevent it from warping and rendering the draught uncertain.[130] After a series of experiments, the block trail carriage was introduced for the 3-pounder Desaguliers, 6-pounder Belford, and probably the 5-1/2-inch howitzer when the Horse Brigade of the Royal Artillery was formed in 1793.[131]

Although initially introduced for horse artillery, the block trail carriage was soon extended to all field guns. By 1813, the medium 12-pounder, 9-pounder, heavy and light 6-pounders, and the heavy 3-pounder were all said to be mounted on the new pattern carriage.[132] As well, the light 3-pounder was similarly mounted, but on wheels 4 feet 4 inches in diameter rather than 5 feet.[133] Undoubtedly double bracket carriages were still issued as long as they were in store, but by the end of the Napoleonic war the revolution in field carriage design was complete.[134]

Neither tables of dimensions nor a formula for the construction of the block trail carriage have been discovered, but very good illustrations of carriages for various calibres have been found. Shuttleworth, a student at the Royal Military Academy, has left a portfolio of drawings, circa 1820, including a plan and elevation of the carriage of a light 6-pounder and an elevation of the carriage and limber of a medium 12-pounder (Figs. 151, 152, and 153).[135] The drawing of the latter carriage showed an extra pair of trunnion holes cut in the brackets toward the rear of the carriage for the gun to rest in when limbered up for travelling. Moving the gun into these "travelling" trunnion holes moved the centre of gravity toward the limber, making for a more stable carriage especially in hilly country or over rough roads. In 1846, plans and elevations of the carriages and limbers for 12-, 9-, 6-, and 3-pounder field guns were published in the Aide-Mémoire; a plan and elevation of the 9-pounder carriage, differing in some details, was published in the second edition of 1853.[136] Finally, in the 1860s the Royal Carriage Department published a series of definitive drawings of artillery carriages, limbers, and other vehicles (Figs. 154, 155, 156, and 157).[137]

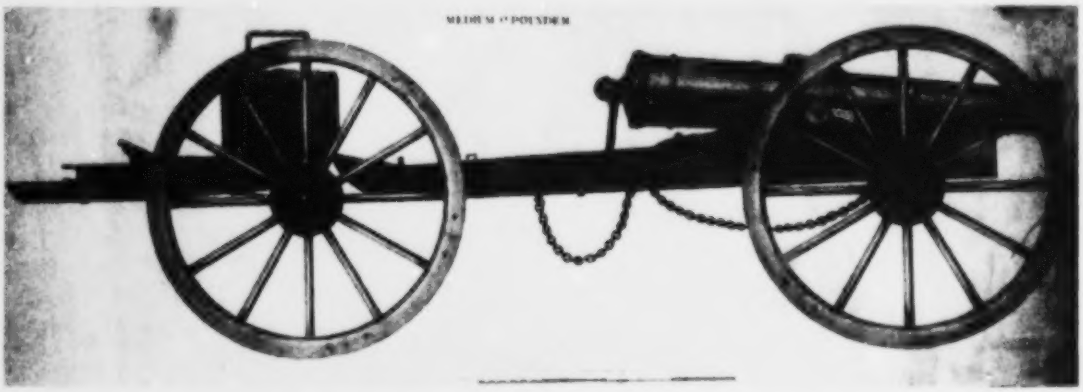


Figure 151. Medium 12-Pounder, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

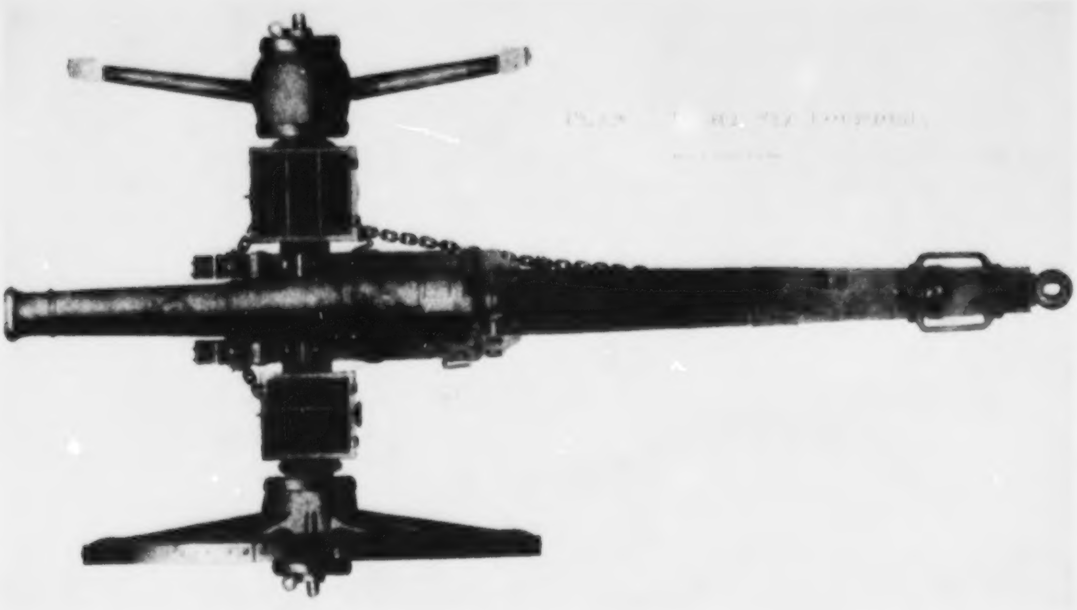


Figure 152. Plan of a Light Six-Pounder, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

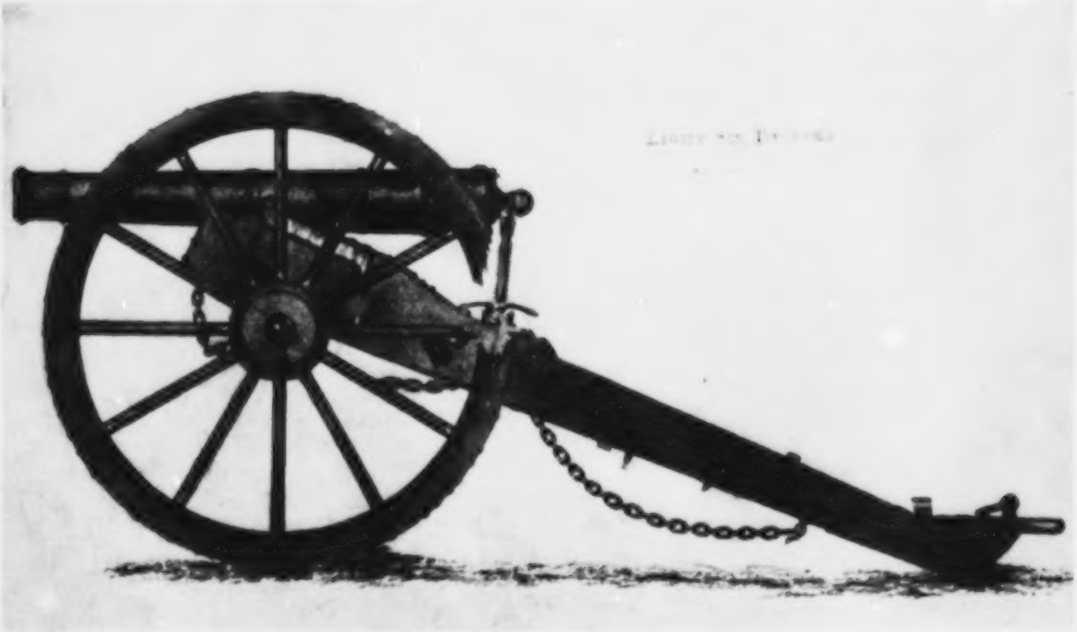


Figure 153. Elevation of a Light Six-Pounder, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

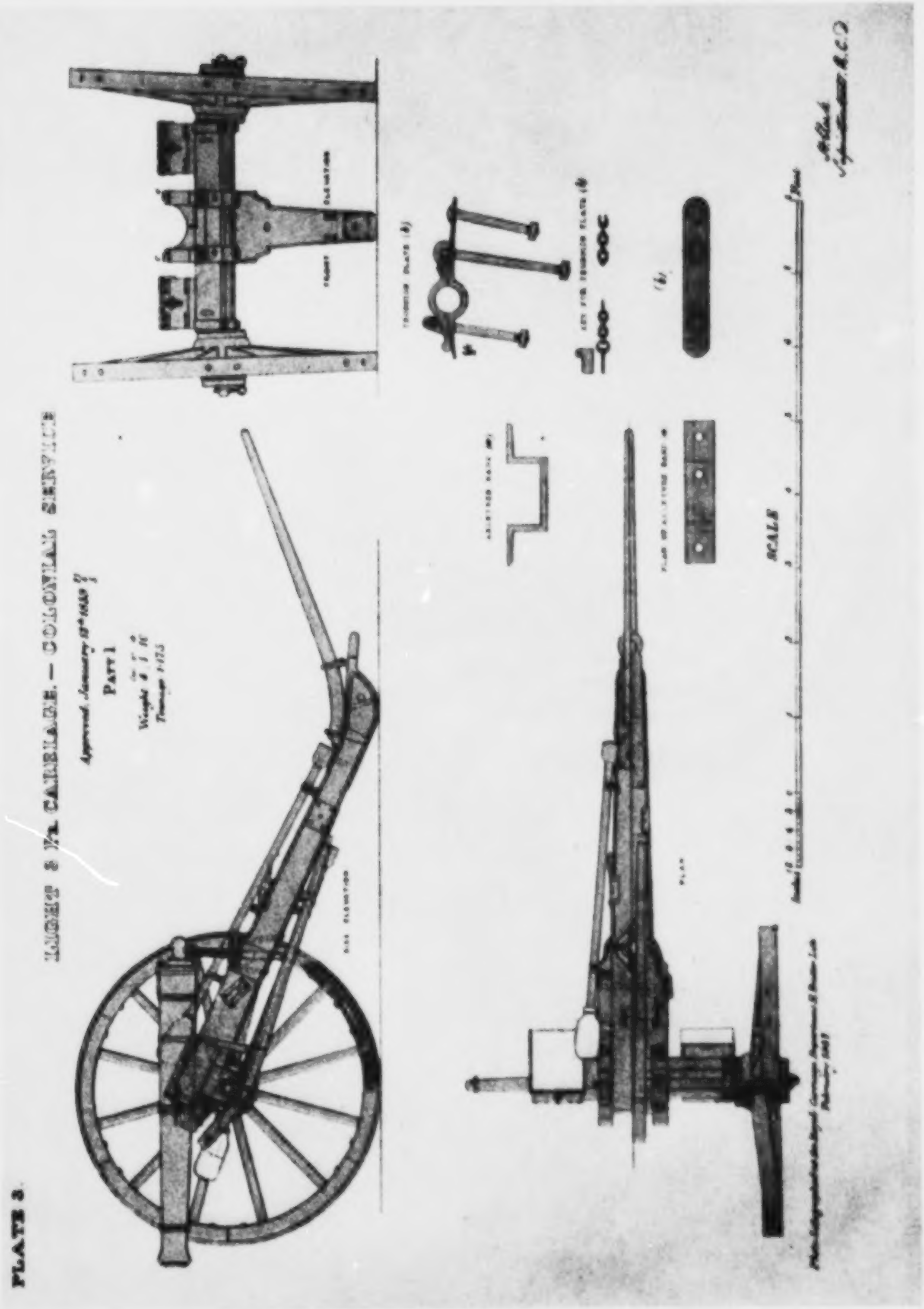


PLATE 3
LIGHT 3 Pr CARRIAGE. – COLONIAL SERVICE
Part I
SIDE ELEVATION
FRONT ELEVATION
PLAN
SCALE

Figure 154. Light 3 Pr. Carriage - Colonial Service. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 3, February 1867.)

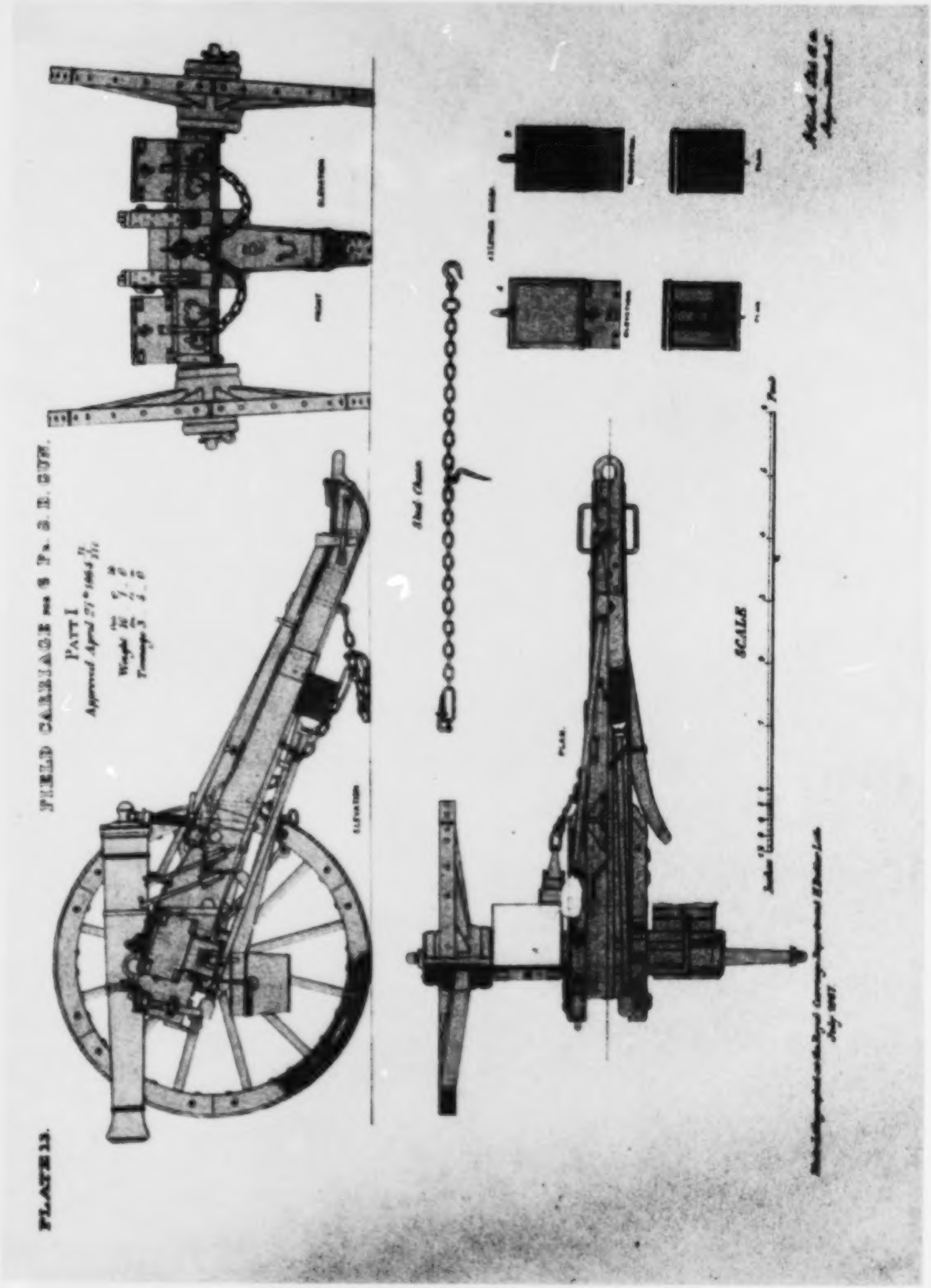


PLATE 13.
FIELD CARRIAGE FOR 6 PR. S.B. GUN.
PATT I
Approved April 21st 1864
ELEVATION
FRONT
ELEVATION
PLAN
Shot Chain
SCALE
Feet

Figure 155. Field Carriage for 6 Pr. S.B. Gun. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 13, July 1867.)

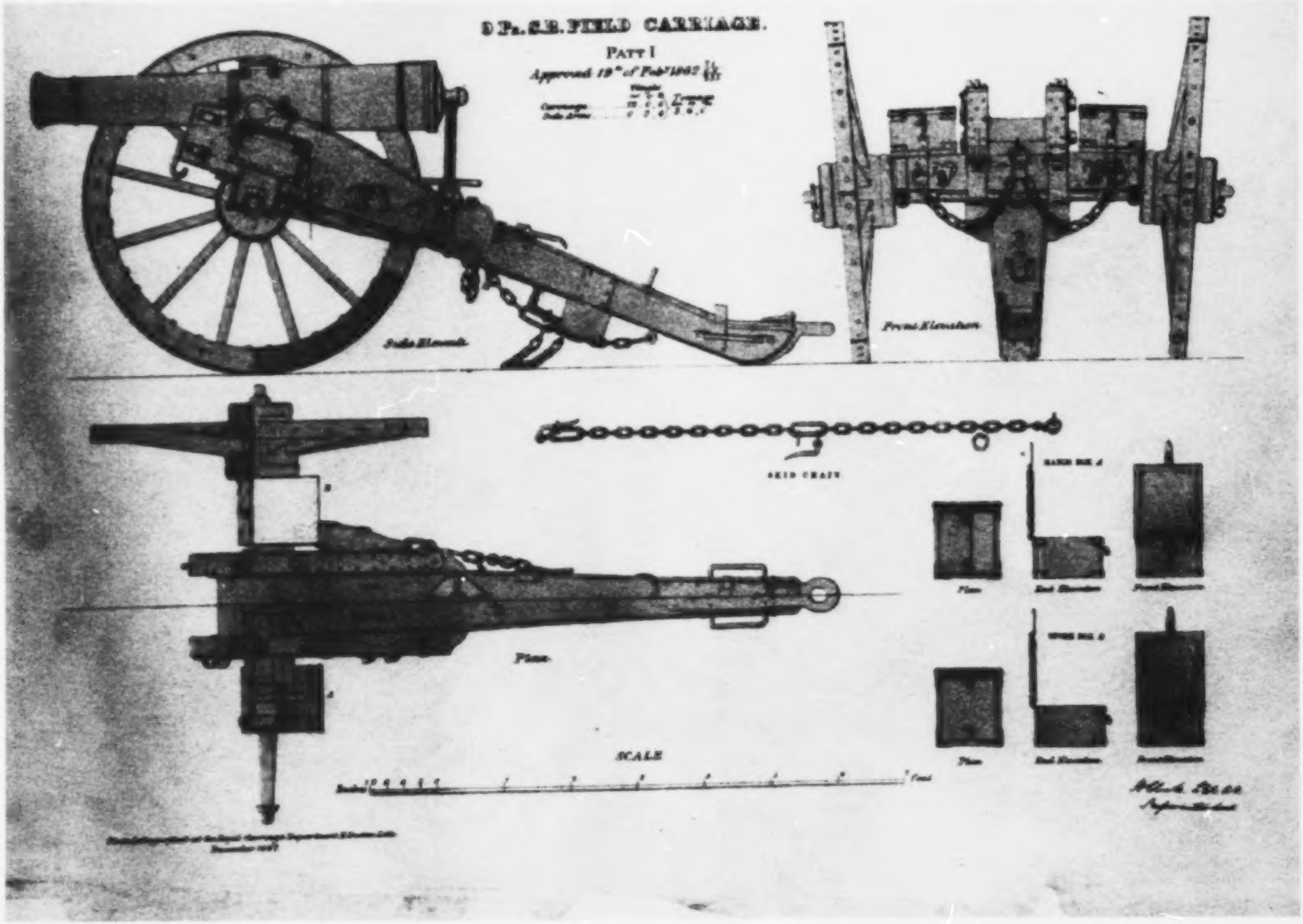

9 Pr. S.B. FIELD CARRIAGE.
Patt I
Approved 19th of Feby 1862
Side Elevation
Front Elevation
SKID CHAIN
Plan
SCALE
Plan
End Elevation
Front Elevation
Plan
End Elevation
Front Elevation

Figure 156. 9 Pr. S.B. Field Carriage. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 14, December 1867.)

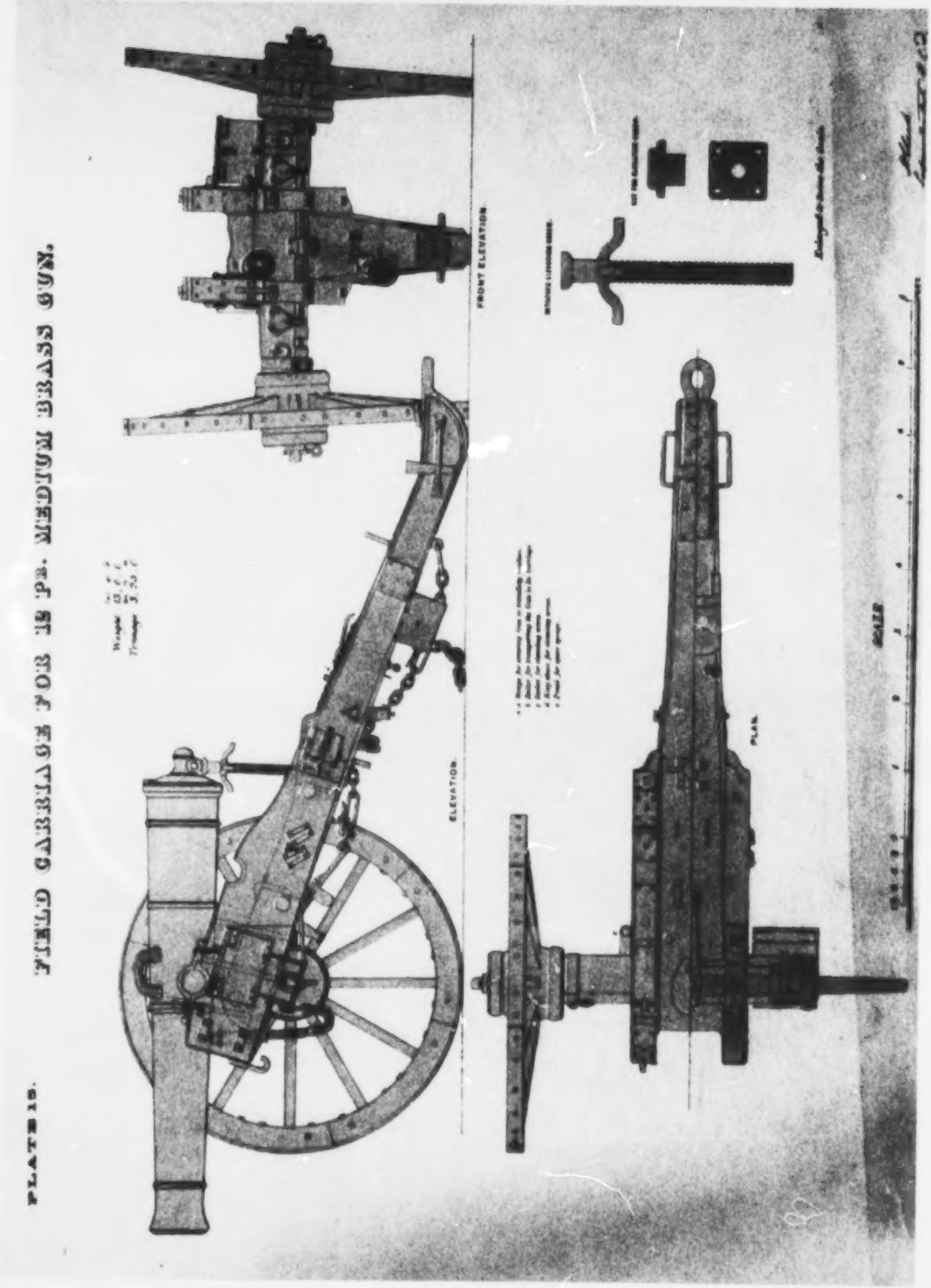


PLATE 15.
FIELD CARRIAGE FOR 12 PR. MEDIUM BRASS GUN.
ELEVATION
FRONT ELEVATION
PLAN
SCALE

Figure 157. Carriage for 12 Pr. Medium Brass Gun. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 15, March 1867.)

Design of carriages for siege artillery or guns of position did not undergo the same changes until the late 1850s, undoubtedly because they did not need to be as light and manoeuvrable as field pieces (Figs. 158, 159, and 160). In 1859, a block trail carriage was approved for the 18-pounder of 38 hundredweight; in 1860 the design was extended to the 32-pounder and 24-pounder of 50 hundredweight, and finally to the 8-inch gun of 52 hundredweight (Figs. 161 and 162).[138]

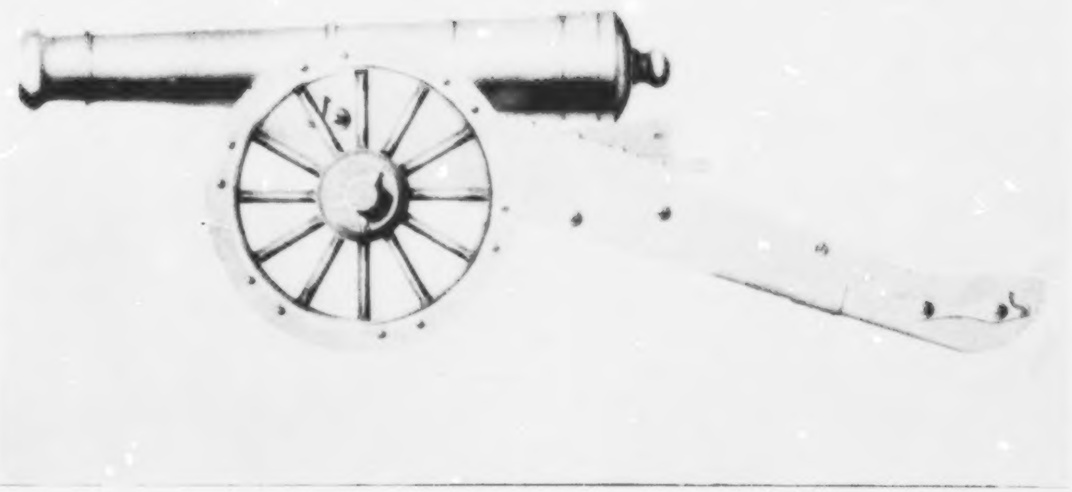


Figure 158. Heavy 24-Pounder on a Travelling Carriage, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

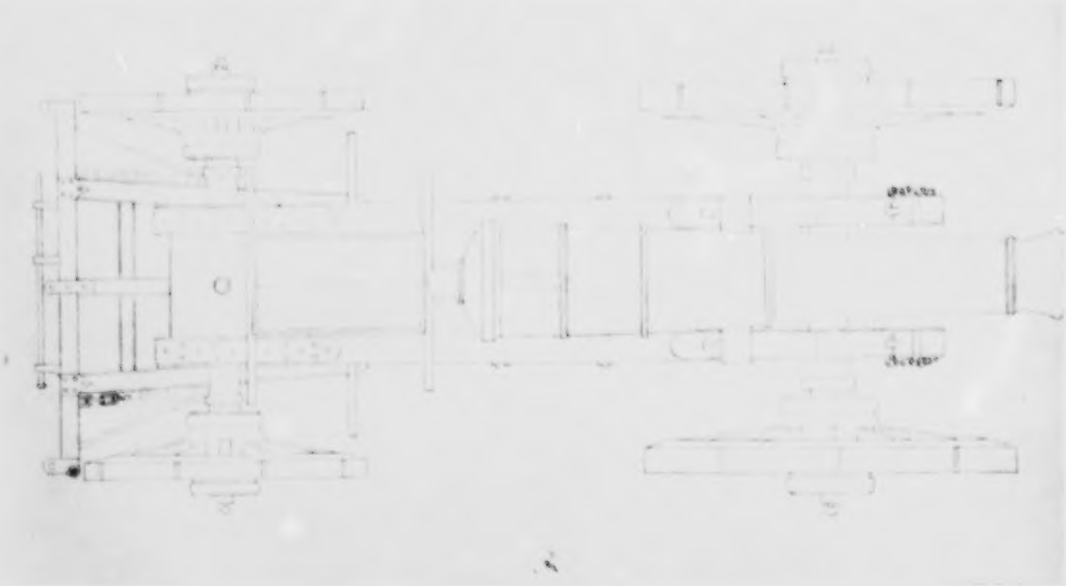


Figure 159. Plan of an 18-pounder Travelling Carraige. (The Royal Artillery Institution, Woolwich, U.K., Greg, Drawings of Guns, Mortars, Howitzers, etc., 1848.)

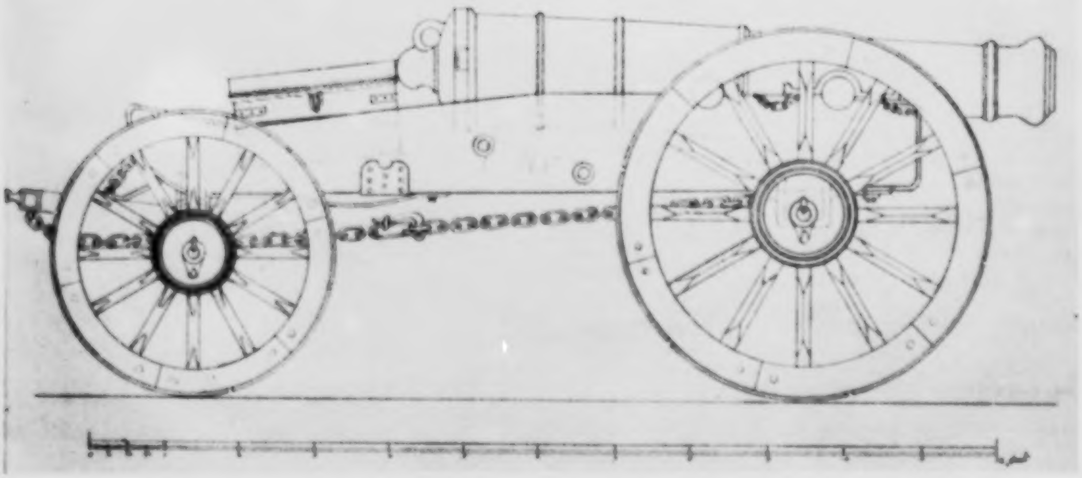


Figure 160. Elevation of an 18-pounder Travelling Carriage. (The Royal Artillery Institution, Woolwich, U.K., Greg, Drawings of Guns, Mortars, Howitzers, etc., 1848.)

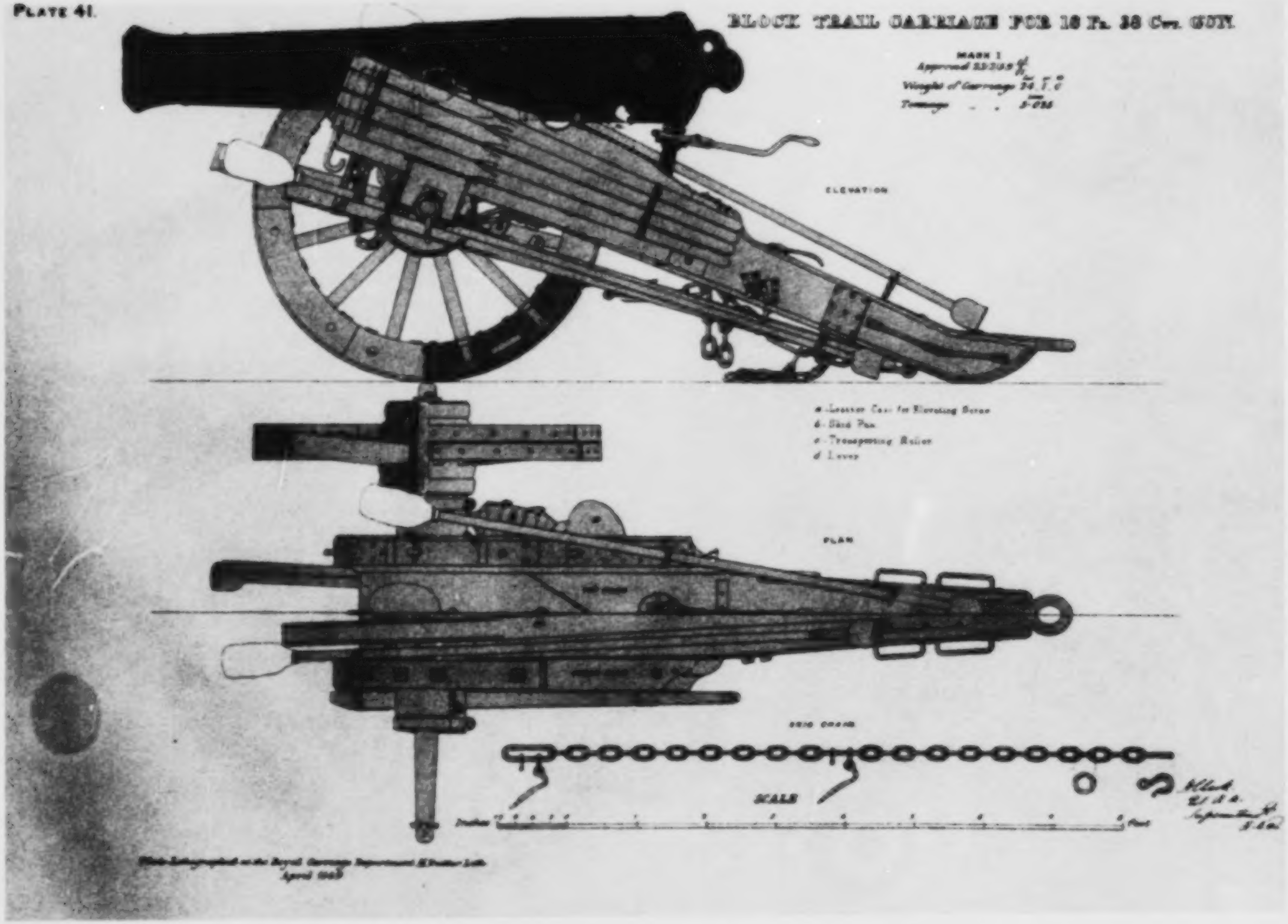


PLATE 41.
BLOCK TRAIL CARRIAGE FOR 18 Pr. 38 Cwt. GUN.
MARK I
Approved
Weight of Carriage
Tonnage
ELEVATION
a Leather Case for Elevating Screw
b Sand Pan
c Transporting Roller
d Lever
PLAN
SCALE
Inches
Feet

Figure 161. Block Trail Carriage for 18 Pr. 38 Cwt. Gun. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 41, April 1869.)

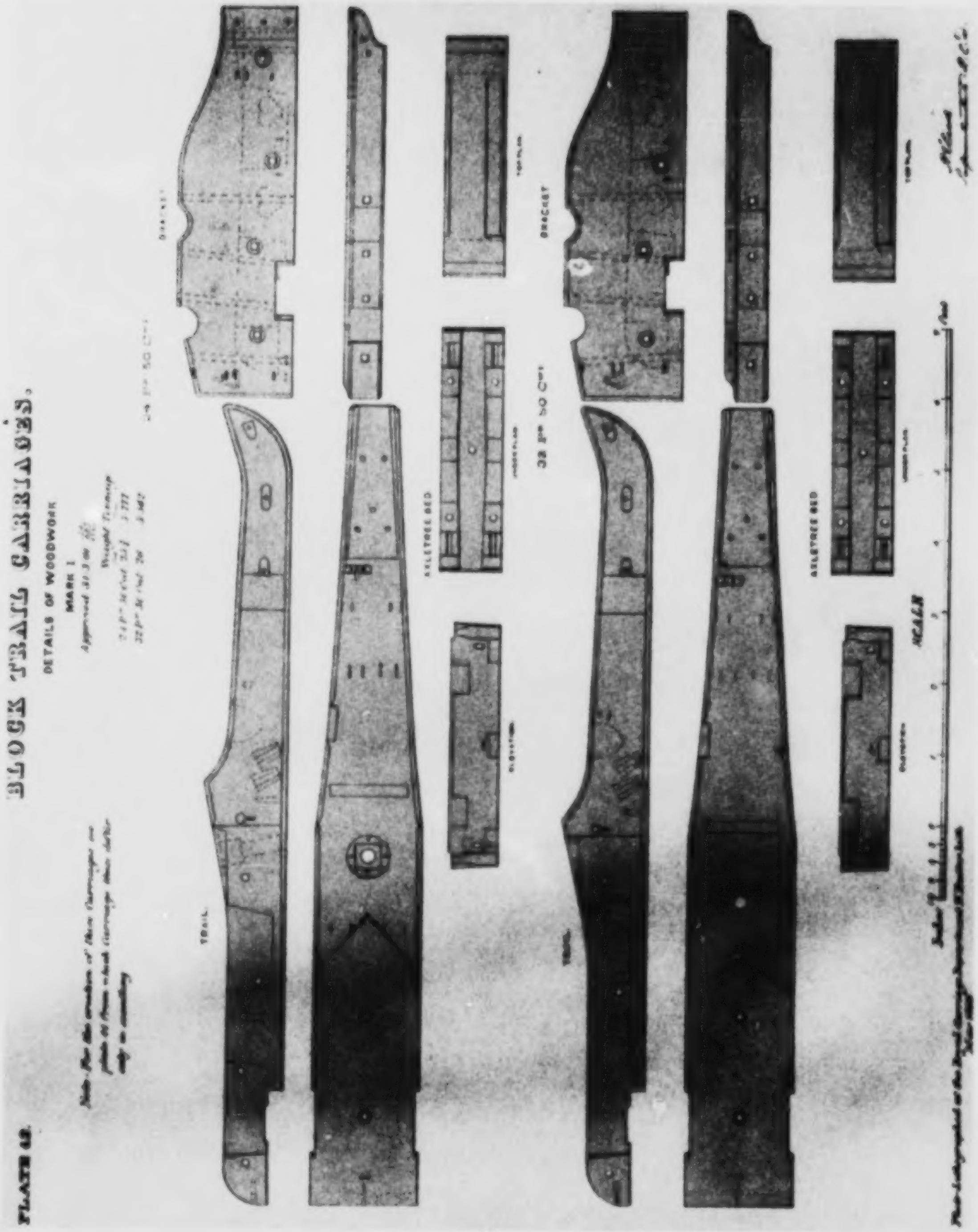


PLATE 42.
BLOCK TRAIL CARRIAGES.
DETAILS OF WOODWORK
MARK I
24 Pr 50 Cwt
32 Pr 50 Cwt
TRAIL
BRACKET
AXLETREE BED
TOP PLAN
UNDER PLAN
ELEVATION
SCALE

Figure 162. Block Trail Carriages. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 42, May 1869.)

Howitzer Carriages

Travelling

The evidence concerning howitzer travelling carriages during the first half of the eighteenth century is limited but valuable. There is a drawing attributed to Borgard, circa 1714, of an elevation of a carriage for an 8-inch howitzer (Fig. 163). As well, there are tables of dimensions of the wooden parts and of the iron work for a howitzer carriage according to the Regulation of 1719. These latter tables did not specify the calibre; presumably the 8-inch was intended. The use of these documents should give us a good idea of a howitzer travelling carriage, circa 1720.[139]

Generally the construction of the carriage was similar to those for guns, but there were minor variations. There were only three transoms – fore, middle, and trail – rather than four, and the carriage did not have any lockers. The iron work was the same, except that the table specified two fore riveting bolts through the brackets instead of the one called for in gun carriages.

The brackets of the carriage of the 1714 drawing were about 7-1/2 feet long, but the Regulation of 1719 called for brackets 10 feet in length, a significant difference. Later carriages of the 1750s and 1790s, while longer by a foot than in 1714, were not that long. A length of 10 feet seems excessive, but it is impossible to check the accuracy of the table which James copied into his notebook in the 1720s.

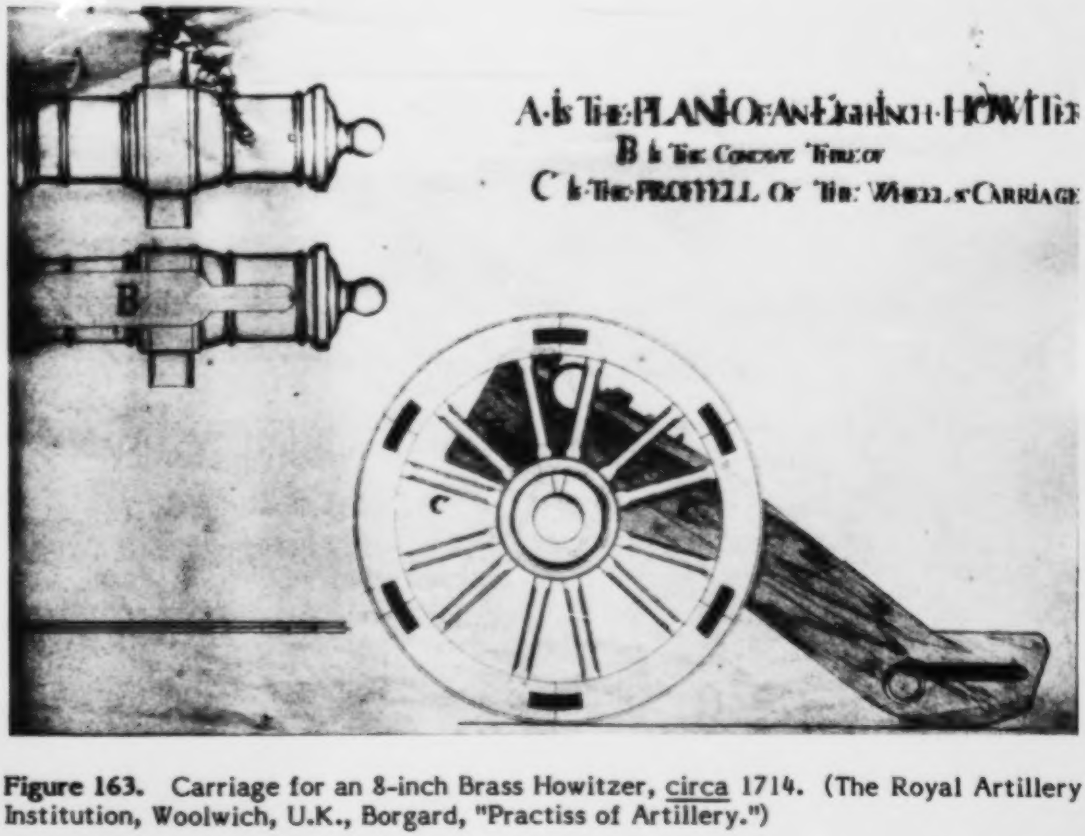

A·Is The PLAN Of An Eight Inch HOWITZER
B Is The Concave Tire of
C Is The PROFILL Of The Wheel & Carriage
B
C

Figure 163. Carriage for an 8-inch Brass Howitzer, circa 1714. (The Royal Artillery Institution, Woolwich, U.K., Borgard, "Practiss of Artillery.")

The drawing also shows a lack of certain pieces of iron work. There does not appear to be a breast plate, a garnish plate, and possibly no middle plate and hook (although the latter may be concealed by the wheel), nor were there side straps or locking plate. It is impossible to know if they were not required or left off through oversight or because the drawing was never completed.

Over the next 40 years there was little change in howitzer carriage design, although there were differences in dimensions. Both Adye and Muiler gave tables of dimensions and drawings of the 8-inch howitzer carriage (Fig. 164). (The smaller howitzer and the 10-inch carriage were noted, but their dimensions were not included in the table.) The most significant difference compared to 1719 was the length of the bracket, 101 inches; its depth and thickness remained the same. As to the iron work, the only change was the loss of the garnish bolts. In 1719 there were two garnish bolts and two garnish nails; Muller and Adye indicated only four garnish nails. If the garnish bolts have vanished then the axletree band, which connected the axletree to the brackets, was held on by the two eye bolts before and the joint bolt behind. Such a method was illustrated in Rudyerd's drawing in 1792.[140]

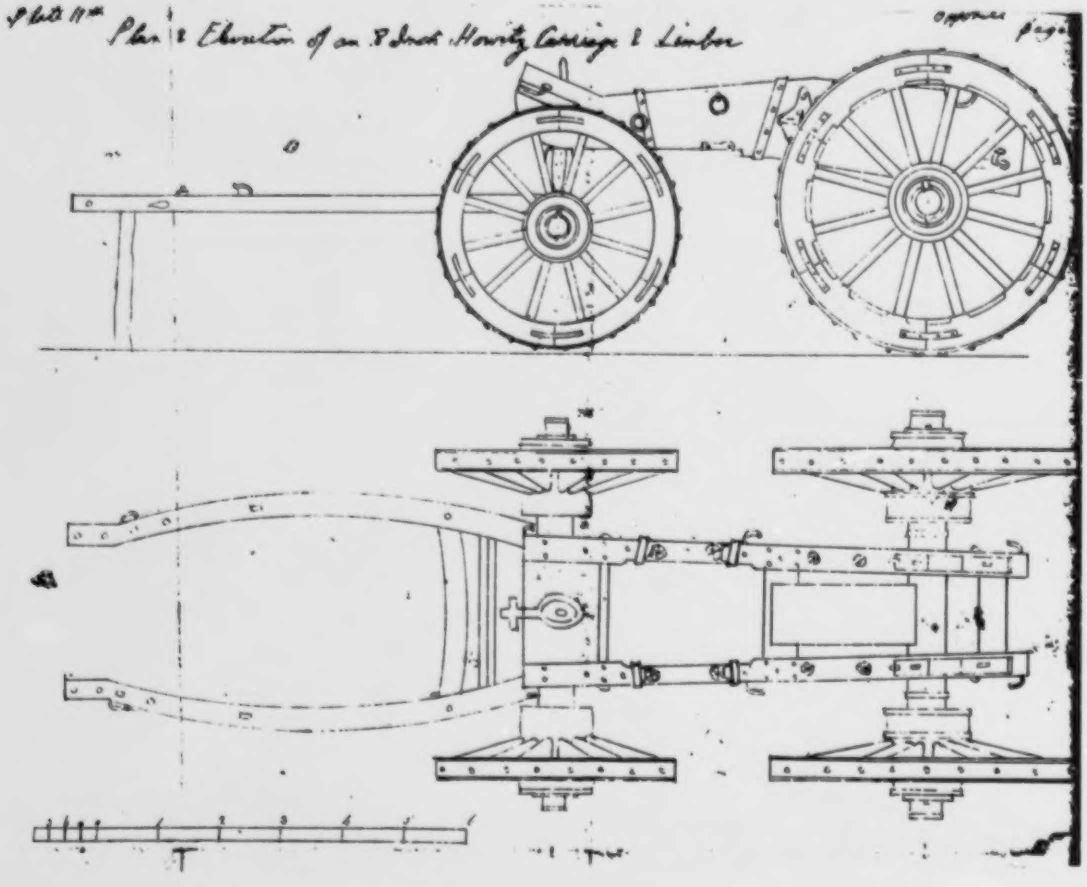


Plate 11th Plan & Elevation of an 8 Inch Howitz Carriage & Limber
opposite page

Figure 164. Plan and Elevation of an 8 Inch Howitz [sic] Carriage & Limber. (The Royal Artillery Institution, Woolwich, U.K., Adye (1766), Plate 11.)

In his dictionary of 1779, Smith provided us with information about the use of elevating screws in howitzer carriages:

> those [carriages] for the 6[sic?] and 5.8-inch howitzers are made with screws to elevate them, in the same manner as the light 6-pounders; for which reason they are made without a bed, and the centre transom must be 9 inches broad to fix the screw, instead of 4 for those made without: in the centre, between the trail and centre-transom, there is a transom bolt, which is not in others, because the centre-transom must be made to be taken out; after which the howitzer can be elevated to any angle under 90 degrees.[141]

This description is not entirely clear, but he may have been describing the arrangement that Rudyerd illustated in his notebook in 1792.[142]

A comparison of the Adye or Muller drawing with the Rudyerd drawing of an 8-inch howitzer carriage, with the exception of the elevating arrangement, indicates that there were no other changes made in carriage design between 1760 and 1790. Undoubtedly the carriages for the 5-1/2-inch, 4-2/5-inch, and 10-inch howitzers would vary only in dimensions from that of the 8-inch.

The revolution in carriage design of the 1790s, when the block trail was introduced, was not confined to field guns. A similar block trail carriage was also developed for the light and heavy 5-1/2-inch and the 8-inch howitzer.[143] The latter weapon, however, went out of service during the Peninsula campaign, and the new carriage for the 5-1/2-inch howitzer, according to Hughes, was not issued.[144] But there is an excellent illustration of it by Shuttleworth, circa 1820 (Figs. 165 and 166).[145] (This weapon went out of service shortly being replaced by the new Millar 24-pounder brass howitzer.) The 4-2/5-inch howitzer remained in use for colonial or mountain service and block trail carriages for it remained available in the 1860s; one variety hooked to a limber, another was attached directly to shafts (Fig. 167).[146]

In the 1820s General Millar introduced his new howitzers, both brass and iron. The brass 12- and 24-pounders, which resembled guns more than they did the older howitzers, were mounted on block trail carriages, very similar to gun carriages, from the onset of their careers.[147] Initially the elevating screw may have been detached, the base ring of the weapon resting on its head; at least this is the way it was depicted in the 1840s.[148] Sometime in the late 1840s or early 1850s, the design of elevating screw was changed; it was bolted to a loop cast under the button of the howitzer. This meant repositioning the elevating screw housing somewhat more to the rear. At the same time the length of cheeks was increased slightly and small changes were made in the nature of the iron work.[149] The final design of the carriages for both the 12- and 24-pounder howitzer was sealed for manufacture in 1864 (Figs. 168 and 169).[150]

In the early 1840s, Dundas introduced a 32-pounder howitzer manufactured along the lines of Millar's design of the 12- and 24-pounder. It too was mounted on a block trail carriage. Unlike the carriages for its lighter sisters, its carriage was equipped with travelling trunnion holes to which it was moved by a roller when limbered up. Between 1840 and 1860 its carriage underwent only minor changes in the ironwork; the detached elevating screw was retained throughouts its career (Fig. 170).[151]

Millar also introduced 8- and 10-inch iron howitzers in the early 1820s and along with them the distinctive perch trail travelling carriage.[152] The only information available about these carriages at that time was their weight, 22 and 29-1/2 hundredweight respectively.[153] Because this was 2 hundredweight less than the weights given for them in the 1840s and later, undoubtedly some changes had been made but probably of no great significance.

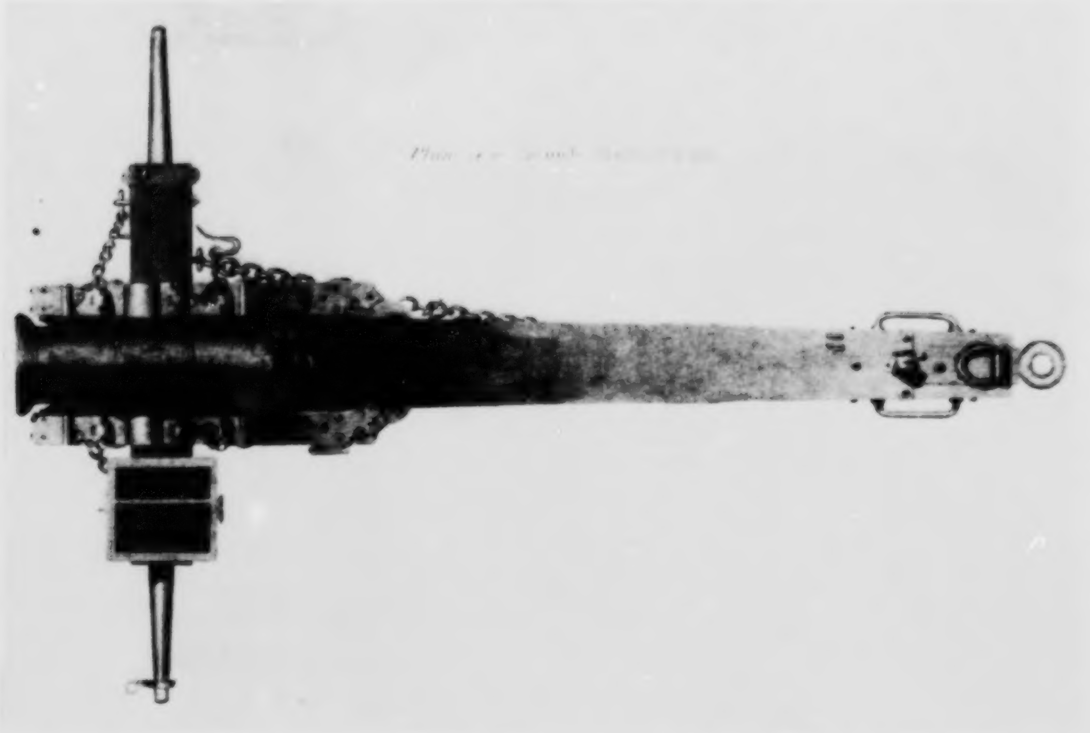


Figure 165. Plan of a 5-1/2-inch Howitzer Carriage, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

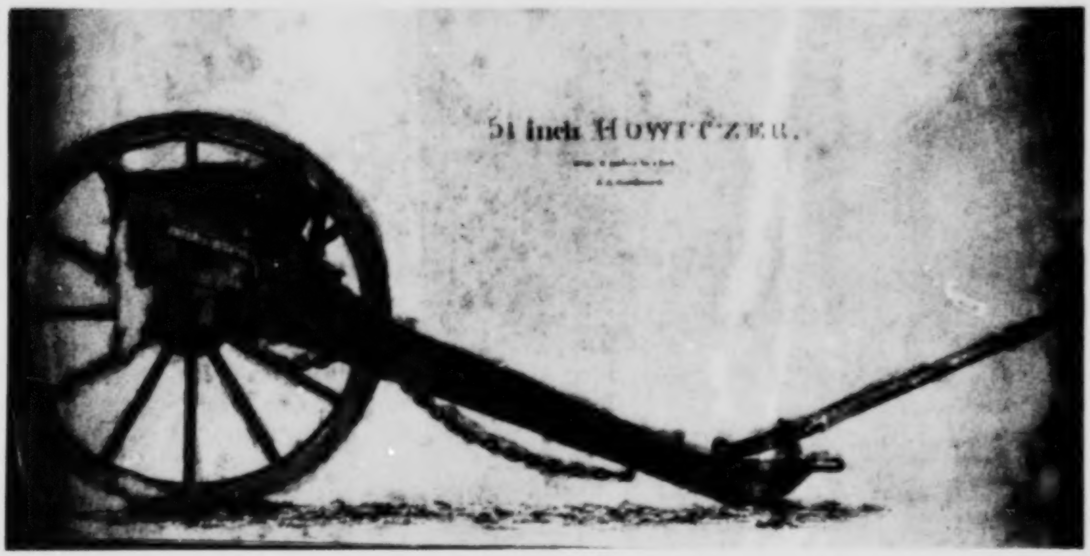


Figure 166. Elevation of a 5-1/2-inch Howitzer Carriage, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth, Drawings.)

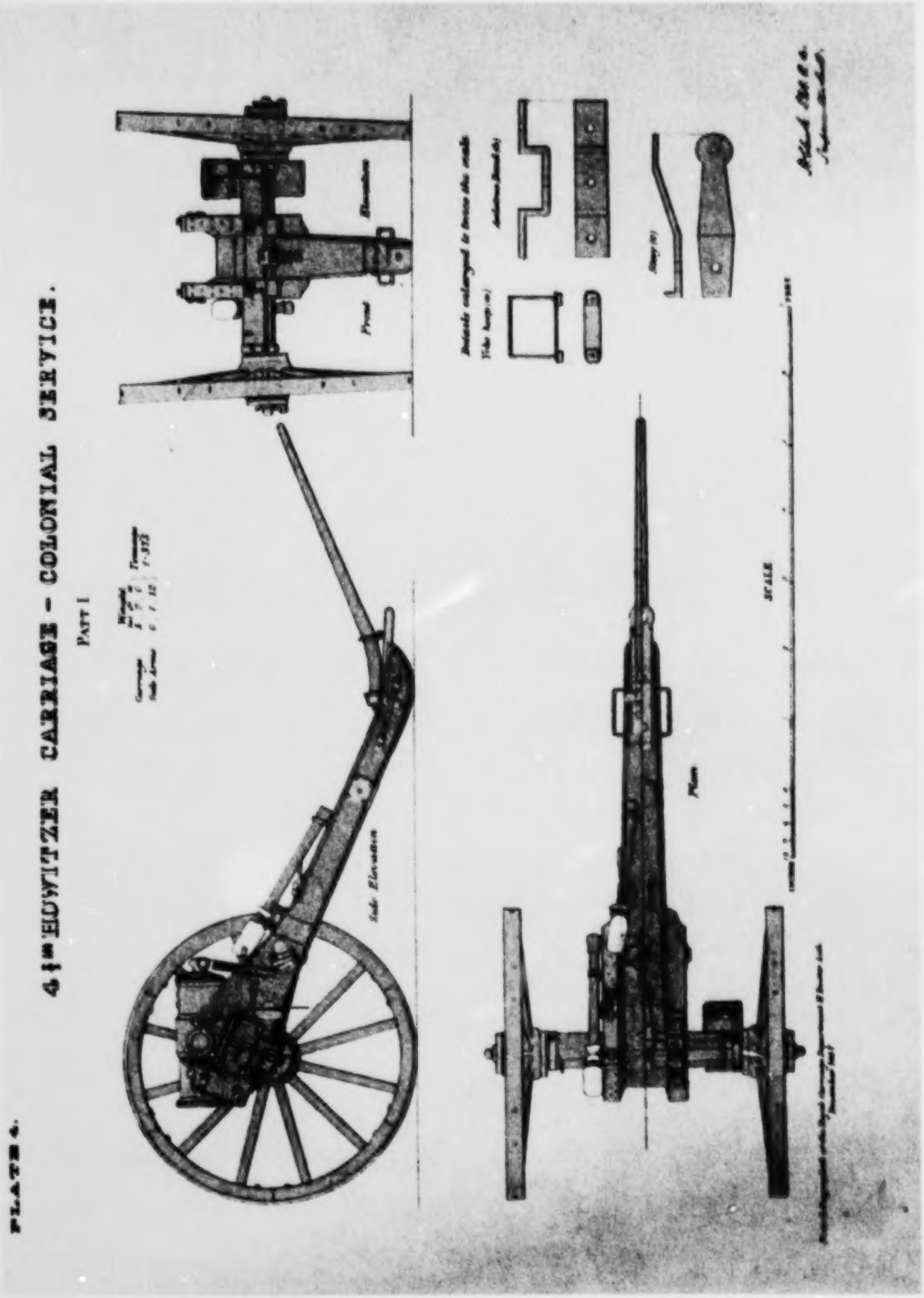


PLATE 4.
4 2/5 in HOWITZER CARRIAGE - COLONIAL SERVICE.
PART I
Side Elevation
Front
Elevation
Plan
SCALE
Details enlarged to twice the scale

Figure 167. 4 2/5 In Howitzer Carriage - Colonial Service. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 4, December 1867.)

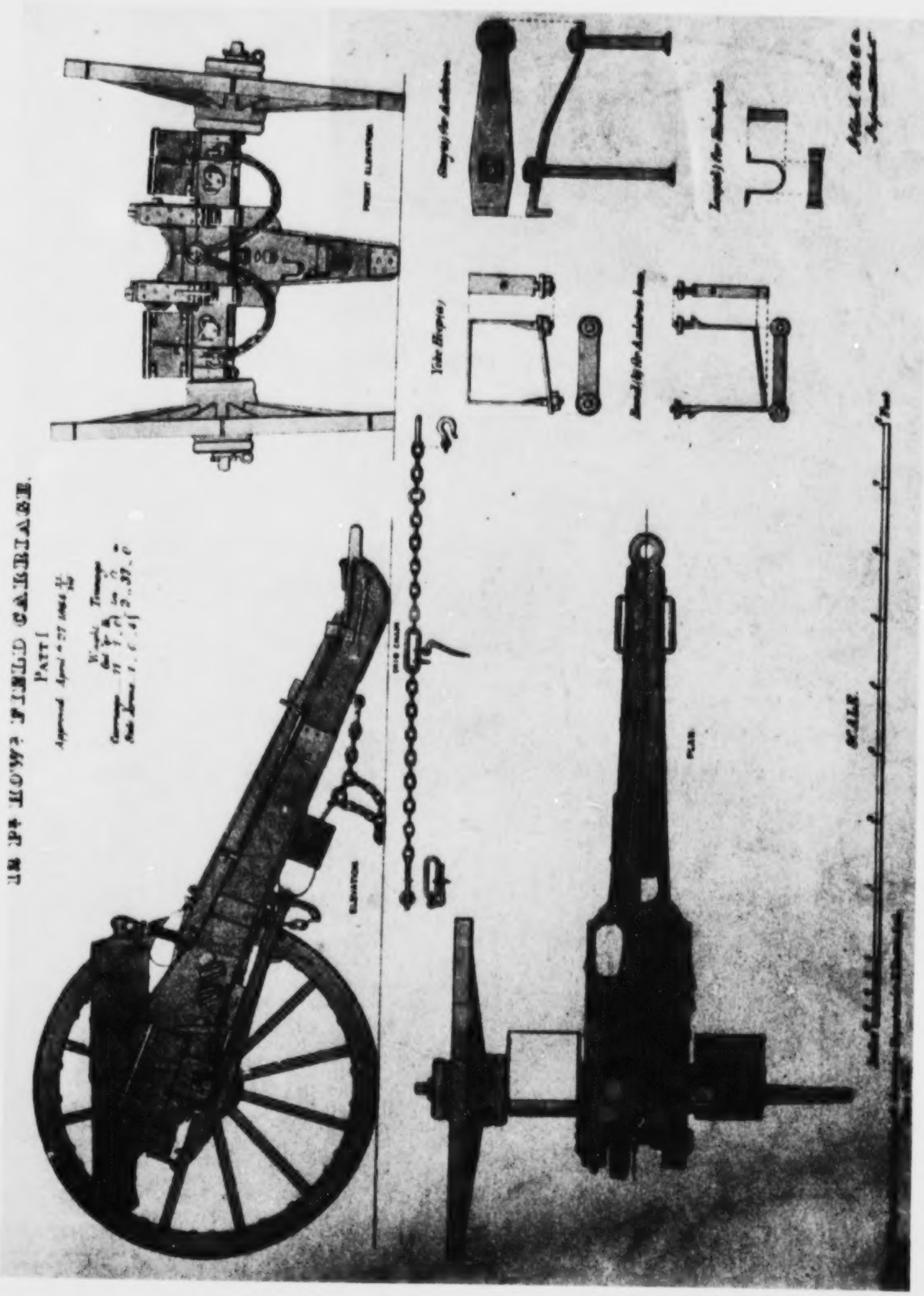

12 Pr HOWR FIELD CARRIAGE
Part I
ELEVATION
FRONT ELEVATION
DRAG CHAIN
PLAN
SCALE

Figure 168. 12 Pr. Howr. Field Carriage. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 16, June 1867.)

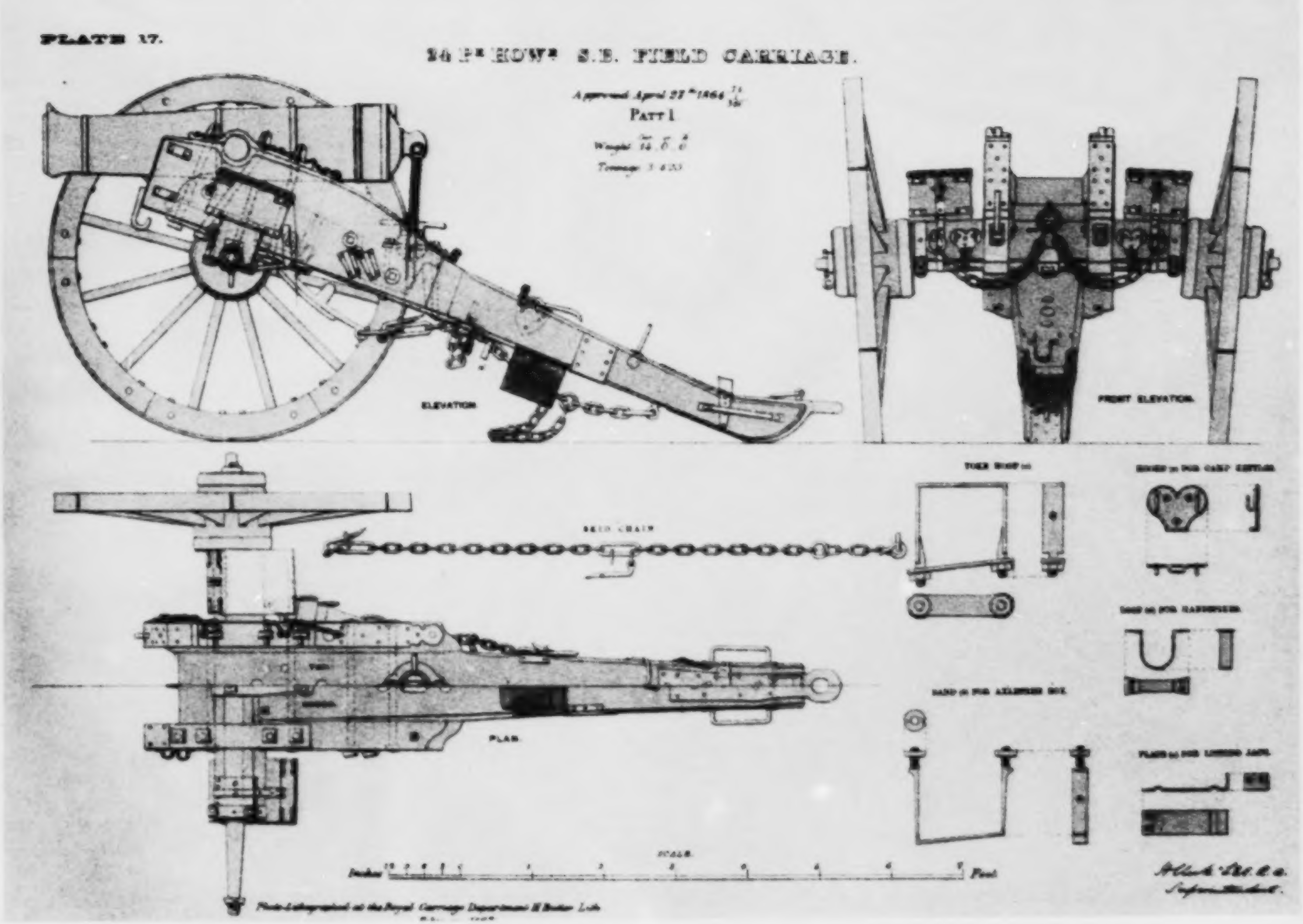


PLATE 17.
24 Pr HOWr S.B. FIELD CARRIAGE.
Approved April 27th 1864
Patt I
Weight 14 . 0 . 0
Tonnage
ELEVATION
FRONT ELEVATION
SKID CHAIN
PLAN
SCALE
Inches
Feet

Figure 169. 24 Pr. Howr. S.B. Field Carriage. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 17, February 1867.)

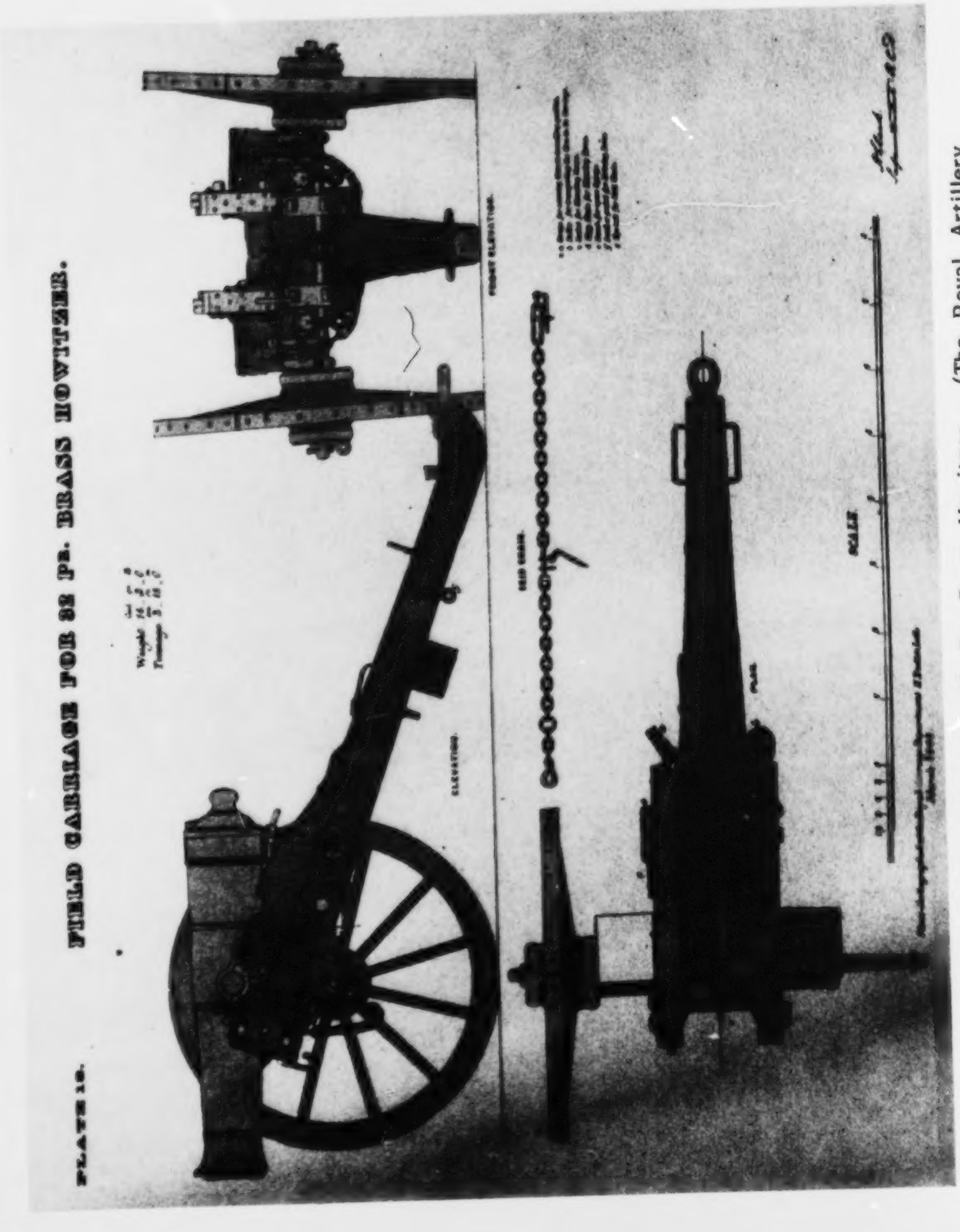


PLATE 18.
FIELD CARRIAGE FOR 32 PR. BRASS HOWITZER.
ELEVATION.
FRONT ELEVATION.
PLAN.
SCALE

Figure 170. Field Carriage for 32 Pr. Brass Howitzer. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 18, March 1867.)

These carriages were much like the double bracket gun carriages, but the brackets were shorter and set further apart (Fig. 171). They were joined by three transoms and bolted together. Attached underneath the rear and middle transoms and extending about 3 feet behind was a slender perch trail on the end of which a trail eye was bolted to fit over the straight pintle of the limber. An axletree on which two iron trucks fitted was bolted to the undersides of the rear of the brackets. These trucks served to keep the perch off the ground when the carriage was unlimbered and aided in running up. To reduce recoil, a wooden lever, which was shaped to fit over the nave of the wheel, was bolted to the front of each bracket. When these levers were compressed on the naves and bolted into place at the other end, the friction between them and naves reduced the recoil greatly. Also, although it was rarely necessary, two wedges could be hammered over the rear trucks for the same purpose. The elevating screw, on whose head the howitzer rested, was fixed into the centre transom; by the 1860s the screw supported a narrow metal swing bed pivoting on a staple bolted through the front transom. By then these carriages were rarely in use because shell guns were replacing howitzers in the siege train.[154]

Garrison

Because howitzers were developed originally for field or siege work, the first carriages were travelling carriages, but garrison carriages were also manufactured although they are much more obscure. In 1813 Adye referred to "Brass Howitzer standing Carriages" for the 10- and 8-inch howitzers, but the only details he gave were their weights:[155]

	cwt.	qr.	lb.
10-inch	21	1	7
8-inch	16	2	23

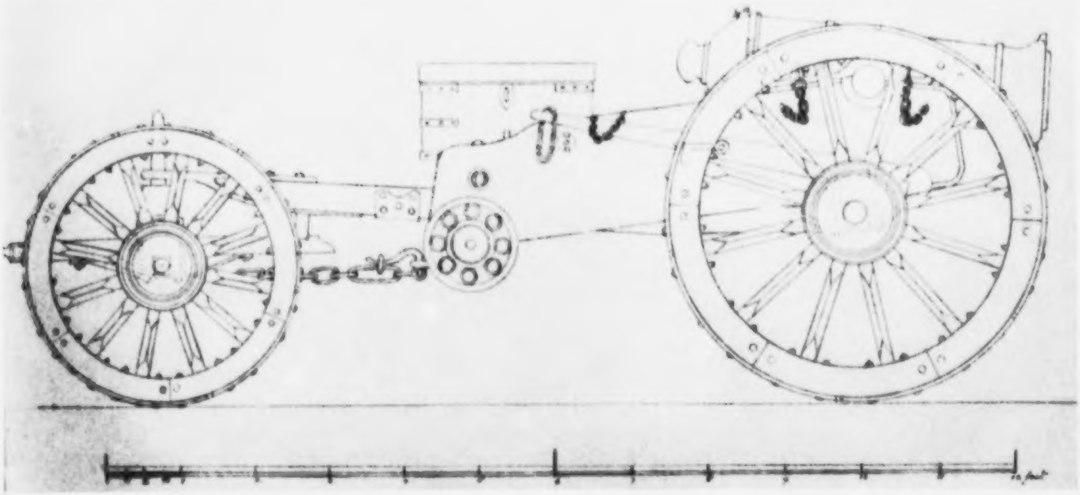


Figure 171. Travelling Carriage and Limber for a 10-inch Iron Howitzer. (Note that the trucks were inside the brackets, not outside as shown.) (The Royal Artillery Institution, Woolwich, U.K., Greg, Drawings of Guns, Mortars Howitzers, etc. 1848.)

In 1825 Mould also gave the weight of garrison carriages for brass howitzers:[156]

	cwt.
10-inch	19 1/2
8-inch	16 1/2

The decrease in weight of the carriage of the 10-inch howitzer of about 1-3/4 hundredweight may have indicted some design changes, but if so they were not likely significant. In the 1860s Miller gave the weight of common standing howitzer garrison carriages at 16 and 15-1/2 hundredweight respectively; these would be for the iron howitzers, of course.[157] In all likelihood a howitzer standing garrison carriage was much like that for a gun, but shorter and wider.

The brass howitzers were replaced by Millar's 8- and 10-inch iron howitzers and the rather obscure 5-1/2-inch or 24-pounder iron howitzer. In 1828 and 1844 Spearman published dimensions for the 8- and 10-inch garrison carriage (Appendix DDD); a scale drawing of the 8-inch carriage appeared in the Aide-Mémoire in 1846.[158] This carriage was composed of two wooden brackets on top of which were bolted two iron "trunnion boxes" to support the howitzer. A vertical front transom and a horizontal middle transom were housed into the sides and the whole held together by two bolts. At the front the brackets were bolted to an axletree and two iron trucks; in the rear it was bolted to a block. In the illustration the carriage was mounted on a traversing platform and the block was in two parts — a transverse wooden block and two smaller "trail bearings" of cast iron which were bolted under it and rested on the side pieces of the platform.[159] The centre transom was fitted with an elevating screw and there was an eye bolt in each bracket over the rear block. There were no capsquares.

In 1864 Miller said that there were both rear chock and sliding carriages for the 8- and 10-inch howitzers. Other than giving their weight he did not describe them:[160]

	Rear Chock			**Sliding**		
	cwt.	**qr.**	**lb.**	**cwt.**	**qr.**	**lb.**
10-inch	15	0	9	14	1	0
8-inch	12	2	0	12	2	0

Technically speaking, a rear chock carriage was not placed on a traversing platform, and a sliding carriage should have a block at both front and rear. Without further details, it is difficult to known if Miller was referring to the carriage illustrated in the Aide-Mémoire.

There was also a garrison carriage for the iron 24-pounder or 5-1/2-inch howitzer. It was illustated in the Aide-Mémoire of 1846 as a "24 Pounder Howitzer Garrison Carriage." In 1819 Shuttleworth drew what appear to be this same carriage on a traversing platform (Fig. 172). It was quite short, mounted on an axletree and two trucks at the front and a block at the rear. An elevating screw of the detached type was fixed to its centre transom. There were no capsquares.[161] In 1864 Miller referred to a rear chock carriage for the 5-1/2-inch iron howitzer which weighed 7-3/4 hundredweight.[162]

According to Griffiths there were iron garrison carriages, but other than their weight nothing is known about them:[163]

	cwt.	**qr.**	**lb.**
10-inch	25	1	5
8-inch	18	1	18
24-pdr. or 5 1/2-in.	15	1	24

Presumably the same rules applied to their use as to iron garrison carriages for guns.

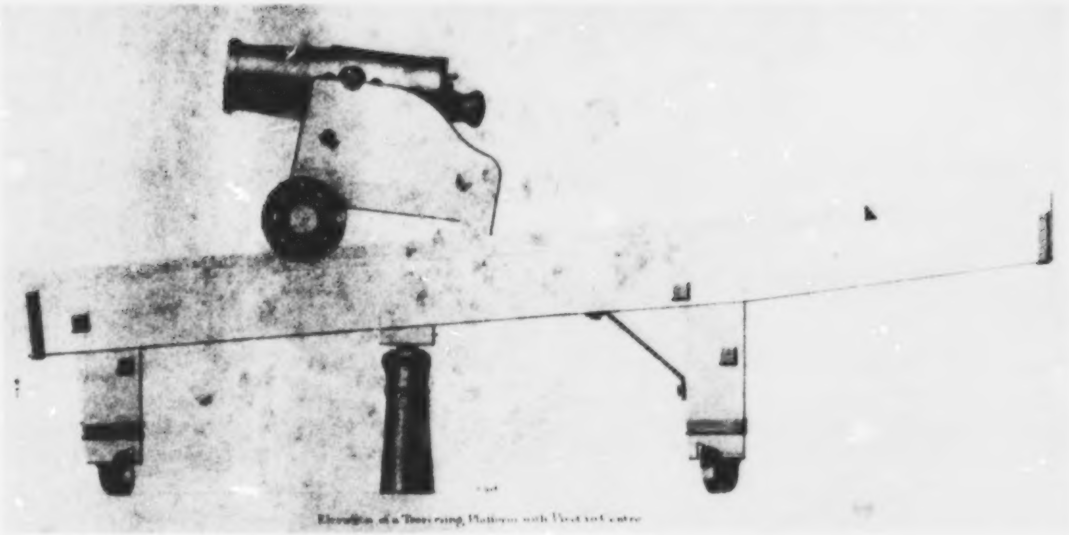


Figure 172. Howitzer Garrison Carriage on a Traversing Platform, circa 1820. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

Carronade Carriage

It was appropriate that the carronade, an innovatively designed piece of artillery, was mounted from its inception on an innovative carriage. Records of experiments conducted at Woolwich in August 1779 referred to a "new constructed sliding Carriage." The carriages made for the 18-pounder carronades of the Spitfire, the first ship to be armed with carronades, were built "upon principles different from everything they [the workmen] had ever seen."[164] So successful was this radical design that it did not change in its essentials over the next 60 to 70 years.

The sliding carriage was made up of two parts. The lower and longer section, that is the slide, was a rectangular block of wood, resting on two transverse chocks at front and back, bolted vertically to the side of the ship. The earliest designs showed both a front and rear chock, but the design published in the Aide-Mémoire in 1846 showed only a rear chock, the front of the slide being supported by the side of the ship. A long slot was cut down the centre of the slide. The upper and shorter section, that is the carriage, which was held in place by a bolt passing down through the slot, recoiled along the slide. Two small cast iron brackets were bolted to the carriage, and the carronade was attached to them by a bolt which passed through them and the loop cast on its underside. The bolt was held in place by a pin through its end. The carronade was restrained on recoil by a breeching rope and run out by tackle, both attached to the ship's side.

It is clear that the sliding carriage could traverse around the bolt attaching it to the bulkhead, but there is conflicting evidence that trucks, or rather small rollers, were attached to the rear chock (somewhat in the manner of a traversing platform) to facilitate the movement. It is true that the earliest illustrations showed trucks attached to the chocks, front and rear, but these cannot have been for traversing since there were attached parallel to the length of the slide. There are as well illustrations that depict small rollers attached to the rear chock which were obviously intended for traversing; but other illustrations show neither trucks nor rollers. Perhaps the design depended on the carronade's location. If it was part of a broadside battery, traversing was usually not required, and thus the carronade was mounted on chocks; even so, traversing could be accomplished with handspikes or tackle if it was necessary. In other positions, say on the poop deck, it might be appropriate to be able to traverse the carronade easily and quickly.[165]

There is a curious statement by Congreve in his An Elementary Treatise on the Mounting of Naval Ordnance in which he seems to indicate that the carriage could be traversed on the slide. In support of his proposed method of mounting carronades he wrote:

> ...That, in this carriage is avoided the traversing motion of the upper bed upon the slide, which exists in the common carriage, and which constantly dismounts these carriages when the upper bed is traversed across the lower slide in firing. In the new carriage the cradle can only recoil in the true direction of the slide, so that no mischief can happen.[166]

An illustration of a sliding carriage published in a Manual for Naval Cadets in 1857 showed a "Pintail" as well as a "Drop bolt" and a "Nut of bolt for groove piece" fitting into the carriage. The term "Pintail" or pintle suggests turning, but it is not clear how it could be possible with a separate bolt and groove piece. The diagram in the Aide-Mémoire, dated 1845, did not indicate a pintle.[167]

The sliding carriage was the usual method of mounting a carronade on shipboard, but there is evidence that truck carriages were also tried. On 20 July 1808, an Admiralty order directed that two carronades on the poop deck were to be mounted on trucks.[168] Philip Broke, who commanded the "Shannon" during the war of 1812, left rough notes indicating that at least he was considering truck carriages.[169] An illustration of "A Brig of War's 12 Pr. Caronade" in 1828 showed the piece mounted on a wooden carriage which recoiled on four trucks.[170]

Although carronades were designed for sea service and achieved their most spectacular successes in naval engagements, they were adopted in the land service as well. They may have been part of the secondary armament of the circular towers built by the British on Minorca between 1798 and 1801. Along with a long gun, two of them were intended to be mounted on traversing platforms on each of the smaller of the prototype Martello towers approved for the south coast of England in 1804 but, because the "ingenious device" to take them turned out to be inadequate, only an 18-pounder gun was put in place. Either carronades or howitzers formed part of the armament of the larger east coast towers.[171] In Canada carronades were mounted on the Martello towers built at Halifax between 1796 and 1815.[172]

It is not clear how the carronades were mounted in Minorca and England, but in the towers at Halifax they were mounted on traversing slides. Detailed drawings or dimensions of these have not been discovered, but the plans of the towers show them on a small scale. They appear to have been naval sliding carriages mounted on long rear legs and trucks and traversing around a front pivot – in effect the sliding carriage adapted to enable the carronade to fire en barbette and turned into a front pivot traversing platform. It is speculation, but it is possible that this method of mounting carronades originated in Halifax, for Prince of Wales, Fort Clarence, and York Redoubt towers were built by 1798, well before the Martello tower program was underway in Great Britain. Carronades were similarly mounted on Georges Island tower when it was completed in 1812, and it was intended to use the same method in Carleton tower in Saint John, New Brunswick, but the cessation of hostilities with the United States made this unnecessary.[173]

In the land service the carronade was usually mounted on a block trail garrison carriage (not to be confused with the field artillery block trail carriage, which was a travelling carriage). The body was a solid more or less rectangular block of wood, bolted to a wooden axletree in front and to a transverse block in the rear. The axletree was supported by two cast iron trucks while the block at the rear rested on the platform. Two cast iron cheeks or brackets were bolted to the body, and the carronade was held in place between them by a bolt passing through them and the loop on the underside of the carronade. The axletree was supported by two diagonal braces, the ends of which were secured by the bracket bolts which passed through the axletree and by two bolts driven through the body to the rear of the brackets. In 1845 these seem to be keyed into place, but they may have been threaded and nutted later on. The carronade was notorious for the violence of its recoil; hence the adoption of a rear block rather than a rear axletree and trucks in an attempt, presumably, to control its recoil.[174]

The first reference found to the carronade block trail garrison carriage occurred in a student's notebook of 1825.[175] Although Adye gave the dimensions and ranges of carronades, he made no mention of their carriages, not even in the 1827 edition of his manual. Possibly, then, the block trail carriage was introduced in the early 1820s. Tables of its dimensions were published in 1828 and 1844 and a scale drawing appeared in 1845; thereafter it continued to be briefly noted (Appendix DDD).[176] Even though the carronade might be used for flank defences or to protect ditches, by the 1860s it was for all intents and purposes obsolete.

The tables of dimensions were published by Morton Spearman in the 1828 and 1844 editions of The British Gunner. The earlier edition omitted dimensions for the carriages of 42- and 32-pounders, but the later edition included those of all calibres from 68- to 12-pounders inclusive. Similarly in 1828 the dimensions of the trucks were not given while they were in 1844. A comparison between the dimensions of the two tables indicates no significant differences although there were variations, the most noticeable being that the lengths of the axletrees in 1828 were consistently longer. Two curious notes were struck in 1844, however. Firstly, the diameters of the trucks for the 68-, 42-, and 32-pounder carriages were put at 19 inches; those for the carriages of the 24-, 18-, and 12-pounders at 18.75 inches. It seems strange that there should have been such a small difference in diameter. Secondly, the bearing, that is the rear block, was said to be cast iron. This would be possible, but it seems unlikely; no other source makes this observation. The scale diagram of the 24-pounder carriage published in the Aide-Mémoire in 1846 does not appear to differ significantly from the 1844 dimensions for that carriage, but it does show certain refinements of design such as the tapering of the body to the rear, and the sloping to the side of the upper surfaces of the rear block and of the axletree bed. It also shows a plate to take the bottom of the elevating screw, although the carronade could be elevated by a quoin as well.

There were iron garrison carriages for carronades, also first noted in the student's notebook of 1825.[177] No record has been found of them for 68- or 42-pounders, and an iron carriage for the 18-pounder was not noted until 1839.[178] Spearman referred to a 6-pounder carriage in 1828, but no other source mentioned it. (Possibly it was an error.)[179] Although only a record of the weights of these carriages has been discovered, because they remained quite consistent (but not entirely so), there were probably few changes in design.[180] A scale drawing of a 12-pounder carriage was published in the Aide-Mémoire in 1845, and an example of a carriage for this calibre is preserved on the grounds of the National Maritime Museum, Greenwich (Fig. 173).[181]

The iron carriage was composed of two brackets, an axletree, a rear transom, two centre transoms, three bolts, and two fore trucks. The brackets, each of which was a frame with a backing, were fitted onto the axletree and the transoms and bolted together, a bolt at the rear, middle, and just behind the loop bolt holes. These were threaded at each end and secured by hexagonal nuts. A pin, the purpose of which is not clear, was driven through the bottom of each bracket immediately below the middle bolt and riveted in place. The trucks were fitted onto the fore axletree and held in postion by two linch pins; as there was no rear axletree, the curved lower surfaces of the brackets rested on the platform.

The iron carriage at Greenwich, which is identified as the "1846 pattern," appears to be identical to the diagram in the Aide-Mémoire except that the centre transoms are missing. In the diagram what appears to be a metal support rests on the two transoms; at Greenwich it rests on the middle and front bolt. On it is a curious metal object on which the elevating screw box of the carronade is resting. These details seem to be makeshifts and not authentic.

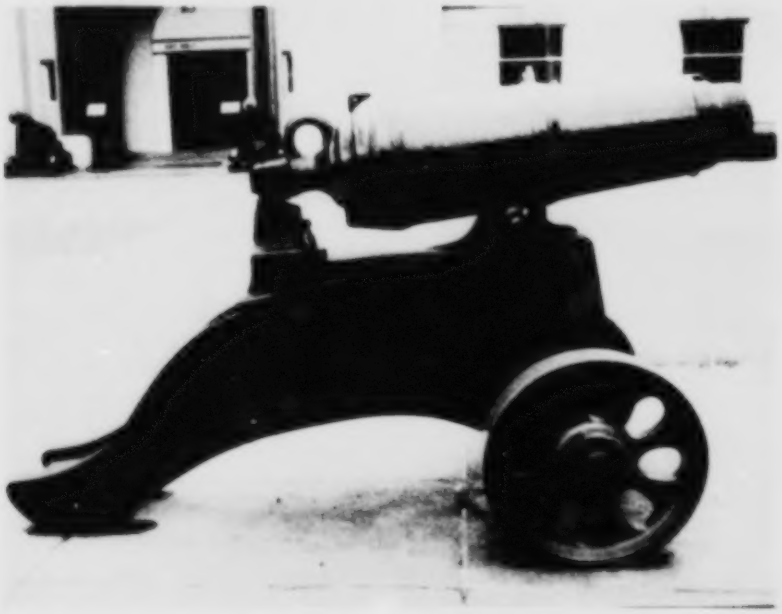


Figure 173. Iron Carriage for 12-pounder Carronade. (National Maritime Museum, London, U.K.)

Limbers

The limber, which was introduced about 1680, was a two-wheeled vehicle to which the carriage could be attached for travelling and from which it could be quickly removed when action was imminent. Because it converted the gun carriage into a four-wheeled vehicle, to which horses could be hitched for draught, the artillery achieved greater mobility and minimized delay in getting into action. As well, the flexible coupling of the carriage to the limber allowed for greater stability when travelling over rough ground. Initially draught was provided by a single horse harnessed between the shafts and the rest of the team linked on in pairs to the front, but by about 1800 an even number of horses was being used.[182]

For over a century the structure of the limber for heavy and medium field pieces remained essentially unchanged (Fig. 174). It consisted of two wheels, an axletree, a bolster, two shafts, two cross bars, and the iron work to complete it. The bolster, which sloped up from its ends to a flat surface on top, was fitted on top of the axletree. It and the axletree were equally mortised in their joint to take the ends of the shafts. The bolster was held in place partly by two hoops which passed around it and the axletree bed; these may have been iron straps bent on and nailed in place with dog nails.[183] Two bolts passed down through the bolster, the ends of the shaft, and the axletree bed; these were keyed into place. An iron plate fitted over the flat surface of the bolster and extended, like a double tail, down its front and rear; it was

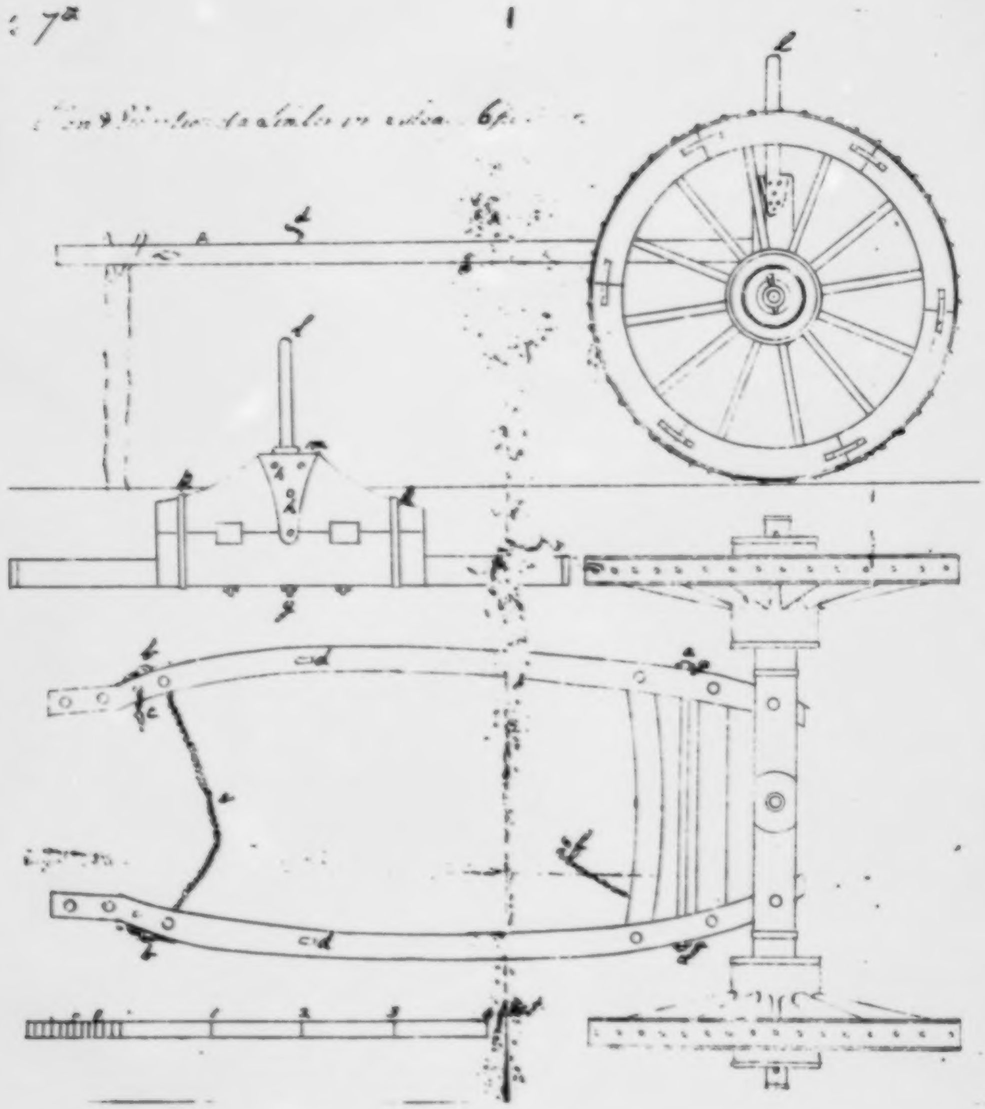


Figure 174. Plan and Elevation of a Limber for a Heavy 6-pounder. (The Royal Artillery Institution, Woolwich, U.K., Adye (1766), Plate 7.)

held in place by eight diamond-headed nails. The pintle, which was shaped so that it rested on the bolster plate to allow about a 15-inch section to project upwards, passed through the plate, bolster, and axletree bed and was keyed into place. A relatively thick iron washer, on which the pintle plate of the carriage worked when it was attached to the limber, fitted over the pintle and rested on the bolster plate. It does not appear to have been fixed in place.

The shafts were slightly carved to be somewhat closer together at the front than at the middle or rear. This shape seems not to have been precisely prescribed and was partly fortuitous:

> All shafts are about two feet open before, two feet ten inches in the middle, and something less near the axletree, according as the wood happens to be more or less crooked; for it is never cut across the grain, because that would weaken it too much.[184]

Two wooden cross bars were fitted into the shafts, bolted and keyed into place. As well, the limber bolt passed through both shafts between the bars and was also secured by a key. To it was attached the limber chain which, when the carriage was attached, passed around the pintle and was hooked onto itself. Also, various chains and hooks were fixed to the shafts for harnessing a horse.

A comparison of the earlier drawings of the heavy limber with Rudyerd's of 1792 indicates that some details, such as the shape of the bolster plate or the exact positioning of the bolster hoops, may have changed. Since no circa 1800 tables of dimensions have been found it is impossible to compare dimensions, but the length of the shafts drawn by Rudyerd are longer, about 102 inches. Also, his limber, which was for a heavy 24-pounder carriage, seems to be of a somewhat lighter construction than that of circa 1760. Undoubtedly there was a greater degree of sophistication in the manufacture of parts and their assembly. In essence, however, the limber of Borgard's time was the same as that detailed by Rudyerd almost a century later.[185]

Although neither Muller nor Smith referred to it, there was also a limber for light field pieces, except for the 3-pounder. This was probably developed about 1750 when artillery began to be used in close support of the infantry. The length of the shafts was 94 inches, the same as that of the heavy limbers, but the dimensions of the other parts were proportionally smaller. Otherwise light limbers were constructed in the same manner as their heavy sisters.[186]

In 1776, along with the new light 6-pounder carriage, a new light limber was also brought into service. The old limber served no other purpose than to support the trail of the carriage; neither men, equipment nor ammunition could be carried on it. It could not turn as short as was required at times to support infantry properly. The diameter of its wheels was so small that on badly rutted roads the axletree often dragged on the ground. The manner of hitching the fore horse to the thill or shaft horse could put so much strain on the latter as to cripple it very shortly. Finally, the nave of its wheels was too small to be placed on the axletree of the gun carriage if the latter's wheels were damaged and, on the other hand, its construction was too weak to allow it to bring the gun off the field.

The design of the new limber responded to these criticisms. The shafts were lengthened, fitted on top of the axletree bed, and extended to the rear. The bolster and pintle were removed from the axletree bed and placed 18 inches behind it, fitted and bolted to the ends of the shafts. The limber bolt was driven through the shafts about halfway between the axletree bed and the ends of the shafts. A wooden cross-bar was joined between the shafts about the same distance before the axletre bed as the bolster was behind. Finally, two slats extended lengthways between the bolster and the fore cross-bar. Two ammunition boxes rested crossways on the platform so created. These had two handles on each end to enable the men to carry them. Upon the upper surface of the shafts between the bolt and the front cross bar two ribbons of iron with holes were attached into which the steady pins were inserted to enable the ammunition boxes to be moved backwards and forwards to counterpoise the trail of the carriage on the principle of the steelyard. A locker underneath the limber held tackle for getting the carriage and limber over difficult terrain. The fore horse was hitched differently to take the strain off the thill horse behind. Finally, the wheels were strengthened to enable the limber to carry the gun out of action if the carriage was disabled; as well, the nave was enlarged to allow it to be put on the axletree of the gun carriage if the latter's wheels were damaged in action.[187]

Although the light 3-pounder of the 1750s may have been mounted on a galloper carriage, it seems likely that the design of limber described above would be used with the carriages upon which Pattison's and Townshend's light 3-pounders were mounted in the 1770s. Townshend's gun could be fitted up alternately as a galloper and Pattison's could be carried on hand spikes, but both carriages were of the traditional double bracket design with a pintle hole through the trail transom. It seems reasonable that the light 6-pounder limber or one very like it would be used rather than the older design if these carriages were to be limbered up. Unfortunately no definite information on a light 3-pounder limber has been discovered.[188]

The evolution of the design of the light limber continued in the 1790s when the block trail carriage was introduced for horse artillery. It has been argued that the new carriage that Congreve brought forward was essentially that which Desaguliers had proposed for a 3-pounder in 1778. It is not clear if the new limber for the block trail carriage originated with Desaguliers as well or if its design should be attributed to Congreve. The Duke of Richmond ordered that the size of the wheels and axletrees of both carriage and limber should be the same when in 1788 he instructed Congreve "to contrive carriages for Field Pieces and Ammunition wagons, capable of accompanying Cavalry as well as infantry."[189]

Although neither detailed tables of dimensions nor plans of this limber have been found, undoubtedly it was essentially the same as it was depicted following the end of the Napoleonic wars. The earliest drawing yet discovered dates from 1825 (Fig. 175); a comparison of it with the limber depicted in the Royal Carriage Department Photo-lithograph in 1867 shows only minor changes in detail (Fig. 176).[190]

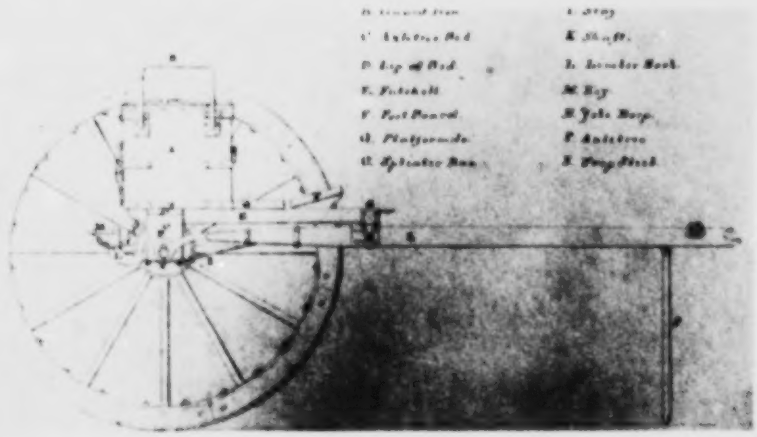


Figure 175. Names of the several Parts of a Limber, circa 1825. (Royal Military College, Mould, p. 156.)

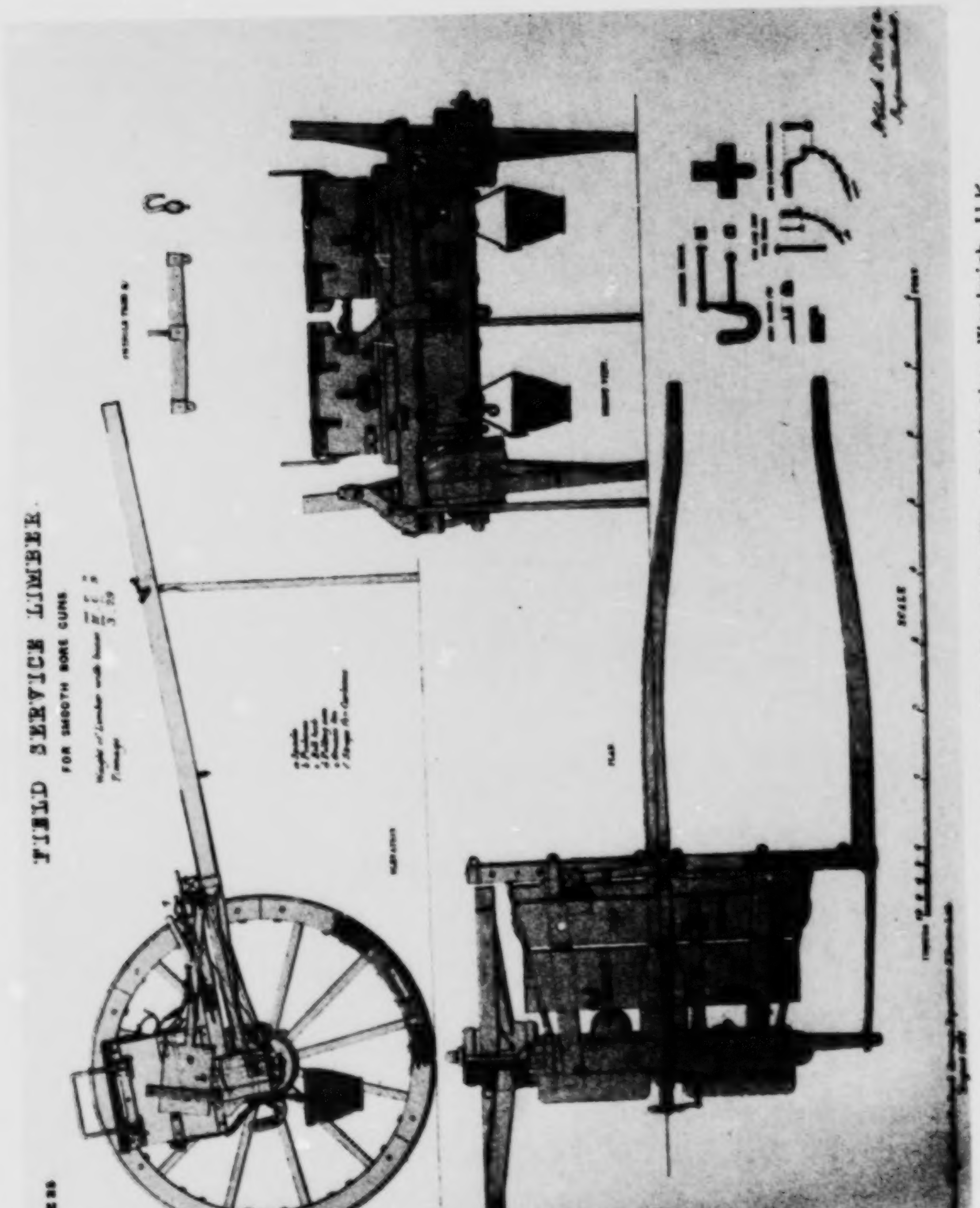


PLATE 25
FIELD SERVICE LIMBER
FOR SMOOTH BORE GUNS
SCALE

Figure 176. Field Service Limber. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 25, August 1867.)

The new limber consisted of two wheels, a wooden axletree bed, three futchells, a splinter bar, a platform board, a foot board, two shafts, and the necessary iron work to hold it together. The iron axletree was fitted into a groove in the bottom of the axletree bed and held in place by two bolts, one on either side of the centre futchell, and by a yoke hoop and coupling plate bolted together at each end of the bed. The straight pintle had been replaced by a crooked pintle, an iron hook attached by three bolts to the rear of the axletree bed at its centre. When the carriage was limbered up, the trail eye was dropped over the hook and held in place by an iron key inserted through a hole in the point of the hook. The key was attached to the axletree bed by a chain and staple.[191] The axletree bed was joined to the splinter bar by three futchells. The side futchells were housed and the centre futchell was mortised into the axletree bed; all three appear to have been mortised into the splinter bar. The side futchells were also bolted through the axletree bed by two bolts. Flat irons, which were finished in eyes to take traces or swingle trees, were bolted over the joints of the futchells with the splinter bar. Two tie irons were bolted to the undersides of the axletree bed and the splinter bar to strengthen this framework further. One end of the iron was attached by the bolt holding the yoke hoop and coupling plate in place, the other through the splinter bar. In the 1850s the iron may have been shifted slightly toward the centre and attached to the splinter bar by two bolts. A platform board was attached by four countersunk bolts toward the centre of the futchells; staples were sunk into it to which pieces of equipment could be lashed.[192] In front of it a footboard was placed held at an angle by two triangular pieces of wood resting on the two outside futchells. By 1860 a board shorter than the splinter bar, called the "slat," was fixed into the futchells immediately behind the splinter bar and jointed to it and the futchells by the flat eye-irons. Its purpose was to prevent a kicking horse getting his hoof between the splinter bar and foot board. It is impossible to tell if the slat was in the 1825 drawing, but it was not shown in those of 1845 or 1852.

The limber was constructed to take either single, double, or even triple draught. Four metal bands or shaft-irons were fitted underneath the splinter bar; six metal eyes for traces or swingletrees were bolted to its upper surface. For double draught, the near shaft passed through the third shaft-iron from the right (at the centre of the splinter bar) and fitted into a mortise or a mortise plate in the axletree bed. It was secured by a bolt which passed through the platform board, futchell, and shaft and was keyed in place. The off shaft passed through the first shaft-iron, at the right end of the splinter bar, and was fitted over the axletree arm by a metal loop on its end, called the wheel iron, that acted as a washer. It was held on by the linch pin. The off horse was harnessed between the shafts and a swingle tree was hooked to the centre eye of the left side of the splinter bar for the near horse. For single draught, the near shaft passed through the fourth shaft-iron, its end resting in a iron stirrup fixed underneath the near side futchell. It was held in place by a bolt that passed through the foot board, futchell, and shaft and was keyed in place. The off shaft passed through the second shaft-iron and fitted onto an iron crutch, analogous to the end of the axletree arm, and held in place by a linch pin. The crutch carried a washer which was transferred to the axletree arm before the shaft was put in place. For triple draught, a swingletree was hooked onto the eyes fitted at each extremity of the splinter bar.[193] The off shaft was equipped with a prop to hold the shafts up in park; in 1862, it was ordered that a second prop be fitted to the near shaft as well.[194] In 1860 the design of the off shaft was modified; its iron extended to the splinter bar, thereby leaving a wider space between the wheel and shaft for mud to work through when the limber was passing over muddy ground.[195]

Two ammunition boxes fitted onto the rear of the limber, resting on the axletree bed and the futchells. They were held in place by the rear edge of the platform board and by two iron stop plates or shoulders attached towards the end of the axletree bed. The 1825 drawings do not show them, but later drawings indicate that two boards were nailed to the rear of the axletree bed for the boxes to rest on as well. A small piece of wood was nailed on top of the axletree, flush with its rear surface to separate the boxes. They were lashed or later strapped into place. Earlier sources indicated a small box was fitted in the space between the large boxes, but it may have vanished by the 1860s. The boxes were equipped with handles on each end and with a guard iron on the side facing outwards. In 1862, it was ordered that this guard iron should be made with a hinge so it could be turned down for stowage on board ship. When in use, it was kept erect by a small key.[196]

This limber was used with the carriages of most field pieces. In 1825 Mould indicated that it was known as the second class limber and listed the carriages with which it was compatible:

> 9 Pounder, Heavy and Light 6 Prs., Heavy 3 Prs., Hy. and Lt. 5 1/2 Inch Howitzers, 24 and 12 Pr. Howitzers; Also for the Gun ammunition, store and forge Waggons and Wheel Carriages.[197]

He also noted the three other classes of limbers, of which the first class was for the 12-pounder gun and ammunition wagon. He did not explain how it differed from the second class, but a drawing by Shuttleworth, circa 1820, shows a medium 12-pounder on a block trail carriage (Fig. 158).[198] Only the side view is given, but the limber appears to be of the same design as the second class with one difference. Although the ammunition box hides it, the trail eye of the carriage is attached to the limber between the boxes and on top of the axletree bed; this suggests that the older straight pintle was used rather than the new, improved crooked pintle. In the 1860s, a source indicated that the limber for the 32-pounder howitzer (a piece introduced in the early 1840s) was the same as for the medium 12-pounder; in 1846, a plan and elevation of the 32-pounder howitzer carriage and limber were published in the Aide-Mémoire.[199] The limber was very similar to that drawn by Shuttleworth, and it was equipped with a straight pintle. The design was the same as the second class limber, but the axletree bed was heavier. The heavier axletree and the straight pintle were probably necessary because of the weight of these weapons, 18 and 17-1/2 hundredweight for the gun and howitzer respectively.

The third class limber was for the light 3-pounder and the 4-2/5-inch howitzer. Other than a brief note on the shafts Mould supplied no more information. "Shafts," he wrote, "are the same for all natures of Field Guns above the Light 3 Pounder, which as well as the Mountain Service Carriage have each a different description." The Aide-Mémoire printed a plan and elevation of the carriage for a light 3-pounder but not of the limber, but it did include some information about it in an accompanying table:[200]

weight	3 cwt. 3 qr. 4 lb.
axletree, length	4 ft. 8 in.
wheels, diameter	4 ft. 4 in.

Given the shortness of the axletree, the limber must have been constructed for single draught. In all likelihood this was the limber of 1825.

The second edition of the Aide-Mémoire in 1853 omitted the drawings of the light 3-pounder carriage, but it continued to print the tabular information without change. Seemingly there were no changes in design until 13 January 1859 when a new pattern carriage and limber were approved for the light 3-pounder for colonial service (Fig. 177).[201] The limber was slightly constructed, furnished with a crooked pintle, and set up for single draught only. It was slightly heavier at 4 hundredweight than the limber listed in the Aide-Mémoire; its axletree was shorter, 4 foot 4.25 inches, and its wheel diameter was less, 4 foot 2 inches. Despite these differences

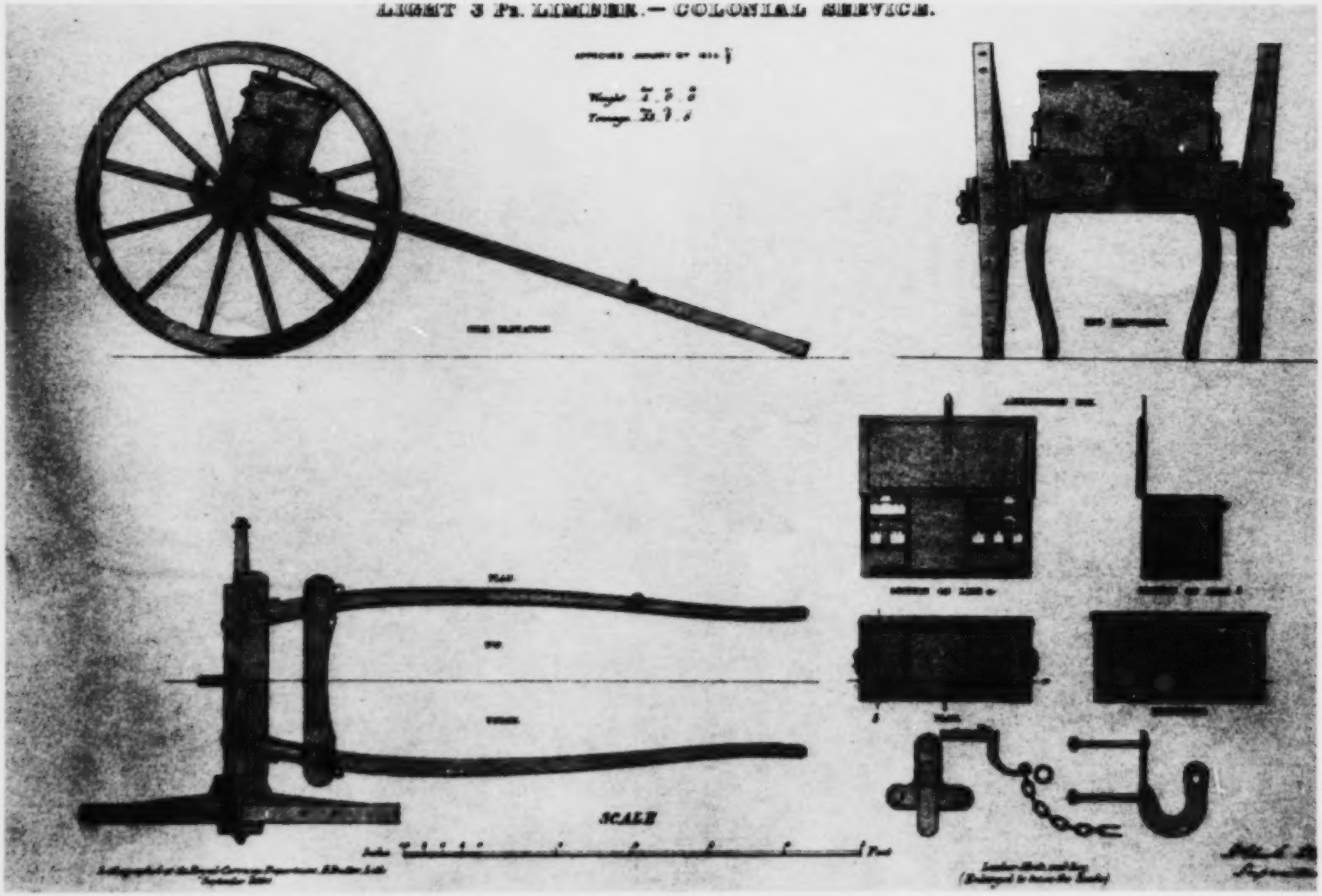

LIGHT 3 Pr. LIMBER.— COLONIAL SERVICE.
SCALE
Feet

Figure 177. Light 3 Pr. Limber-Colonial Service. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 6, September 1866.)

and undoubtedly other minor variations, it must have been very similar to the limber of 1825 and 1845.

Its construction was quite simple. Two shafts, each slightly curved, passed entirely through the axletree bed and were bolted into place. Two bolts, one on each side of the iron axletree which was fitted into a groove in the underside of the axletree bed, were driven through the bed and each shaft. Underneath an axletree support fitted over their ends and was nutted in place. It extended diagonally upwards and was bolted to the shaft. A yoke hoop and coupling plate were bolted together at each end of the axletree bed to contain the iron axletree.[202] Positioned the width of the ammunition box from the rear of the limber, a wooden board was fixed by four bolts across the shafts. The four bolts on each side served to take the end of the axletree support; all four were secured by nuts. The limber carried one ammunition box which was held in place by the cross board and an iron shoulder attached at each end of the axletree bed. It was strapped on by a leather strap passed through a handle on each end and a staple in the side of the shaft. The box did not have guard arms because the limber was not designed to carry men.

The fourth class limber for "The Small arm Ammunition wagon new Limber" need not concern us.

The history of the field limber having been brought into the 1860s, there remains to recount the development of the heavy limber since about 1800. Unfortunately, information is lacking and it is not clear when the heavy limber which Rudyerd had drawn in the 1790s was replaced by a new pattern. It may have been devised in the 1820s when the perch carriages for the Millar 8- and 10-inch howitzers, with which the new limber was associated, came into service. The first clear reference to it was a scale drawing which appeared in Straith's Plans accompanying his Treatise on Fortification and Artillery in 1841.[203] A note in the Aide-Mémoire in 1846 indicated that the same limber was used with the 8- and 10-inch iron howitzers and the 18- and 24-pounder iron guns.[204]

The new pattern limber was composed of two wheels of 3 feet 10 inches in diameter, an axletree bed, a bolster, three futchells, a slat, a splinter bar, a sweep bar and the various pieces of iron-work to hold it together. The bolster rested on top of the axletree and was held in place by the pintle, two bolts (one on either side of the pintle), and a yoke hoop and coupling plate at each end. Three futchells were fitted through the bolster and axletree bed at the joint and were connected to a sweep bar in back and to a splinter bar in front. The futchells were mortised into the splinter bar and held in place by iron bands. The sweep bar was fitted on top of the futchells and bolted into place; its upper surface, upon which the trail of the carriage partly rested, was protected by a strip of iron. Two bolts passed through the bolster, each of the ouside futchells, and the axletree bed; the pintle, of course, passed through the centre futchell. As well, the slot was mortised into the futchells just behind the splinter bar, at about one-third the distance to the axletree bed. The limber was further strengthened by iron stays extending from the yoke hoops and coupling plates to the splinter bar.

The pintle was the straight pattern of the old heavy limber. It rested on a pintle plate fixed to the top of the bolster whose extension sloped forward and was connected to the centre futchell by an eye bolt. The limber chain was attached to this eye bolt in two sections; when the carriage was attached the longer section was looped over the trail and around the pintle and joined to a hook on the end of the shorter section. This chain kept the trail in place, but the strain of the draught was taken by another chain extending from the axletree bed of the limber to the axletree of the perch trucks in the case of the howitzers or to the axletree of the carriage in the case of the guns.

Initially the shafts of the limber may have been attached in the same way as those of the field limber were; Straith's drawing of 1841 showed the near shaft passing through a shaft-iron underneath the splinter bar and fitted into the axletree bed. Presumably the off shaft was fitted through a shaft-iron on the extremity of the splinter bar and over the end of the axletree arm. Thereafter, neither the drawings in the Aide-Mémoire nor in subsequent editions of Straith's work gave any indication of shaft-irons. Instead, splinter bar loops (similar to eye bolts) were passed through the splinter bar and secured by nuts. On the off side a pair of shafts, framed (joined together) were attached by the shaft bolt which passed through the ends of the shafts and the loops, and was keyed into place. On the near side a swingle tree was hooked onto a chain that was attached to the axletree bed to take the harness of the horse.[205]

In 1859 a block trail carriage was designed to take the 18-pounder iron gun and in 1860 the block trail system was extended to the 24- and 32-pounders and the 8-inch gun. It seems likely that a new limber was also designed, but the "Limber for Heavy Batteries" was not approved until 29 January 1862.[206] It is possible that the older limber was used, or there may have been a transitional version of the newer limber in use before the pattern of 1862 was finally approved.

The essential details of the new pattern heavy limber, which resembled the field limber, can be seen in the Royal Carriage Department drawings (Figs. 178 and 179). Its wheels were the same size as those of the carriage, 5 feet in diameter, to provide better traction. It was capable of carrying one small and two large boxes forammuntion and small stores for the 18-pounder. The ammunition boxes of the heavier guns were removed from the limber and carried separately. The shafts for the off horse were attached for double draught in the same way as those of the field limber, but they were not designed to be moved. The near horse was harnessed to a pair of shafts, framed, attached by a shaft bolt to loops driven through the splinter bar. If four horse draught was desired, metal outriggers, which could be unhooked and folded onto the splinter bar when they were not in use, were attached at each end of the splinter bar to which swingle trees were hooked. The pintle, which was a heavy piece of iron bolted to the rear of the axletree bed, appeared to be a combination of the straight and crooked pattern. The trial of the carriage was held in place by the limber chain which was bolted to the axletree bed; it was passed over the trail, around the pintle, and keyed into an eye bolt on the opposite side.

This limber was used for the travelling carriage of the 13-inch mortar, but the old pattern limber was employed with the 8- and 10-inch howitzers on travelling carriages; the latter pieces, however, were largely replaced by shell guns in the siege train by the 1860s. The travelling carriages of the 8- and 10-inch mortars were pulled by a "shell cart limber" which was a modified trench cart. This was a simple platform, with moveable sides, fitted to an axletree. Like the mortar carriage, it took small wheels, 4 feet 2 inches in diameter. It was equipped with five metal cleats any of which could be fitted to the bottom of the cart to enable it to carry projectiles of different calibres; the cleats not in use were strapped to the sides. Two single reversible shafts were fitted for draught. As well, an outrigger was attached at each end of the splinter bar to which swingletrees were hooked if three horses were to be harnessed abreast. The limber was fitted with a variation of the crooked pintle.[207]

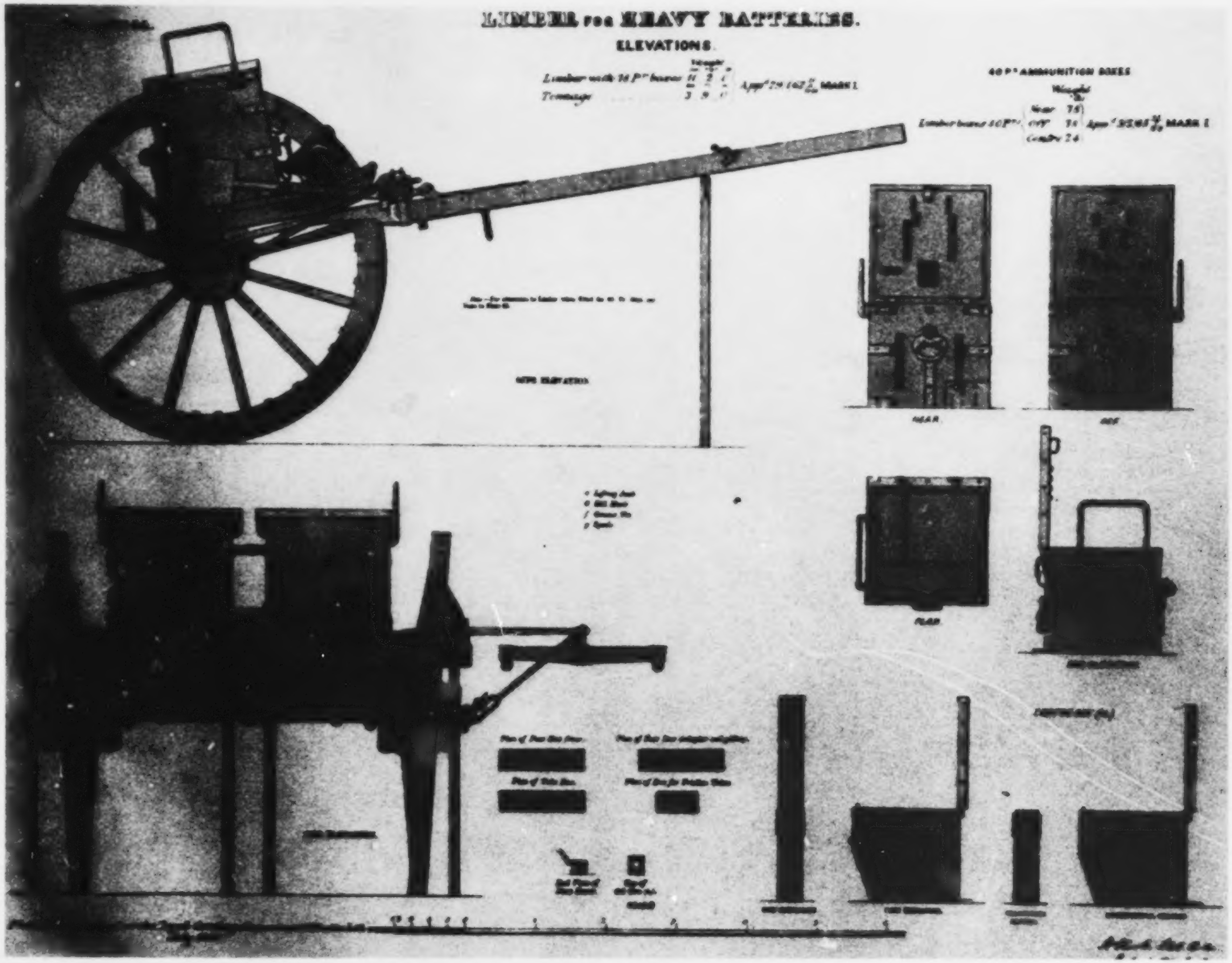

LIMBER FOR HEAVY BATTERIES.
ELEVATIONS.
40 Pr AMMUNITION BOXES
MARK I
MARK I

Figure 178. Limber for Heavy Batteries. Elevations. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 44, July 1869.)

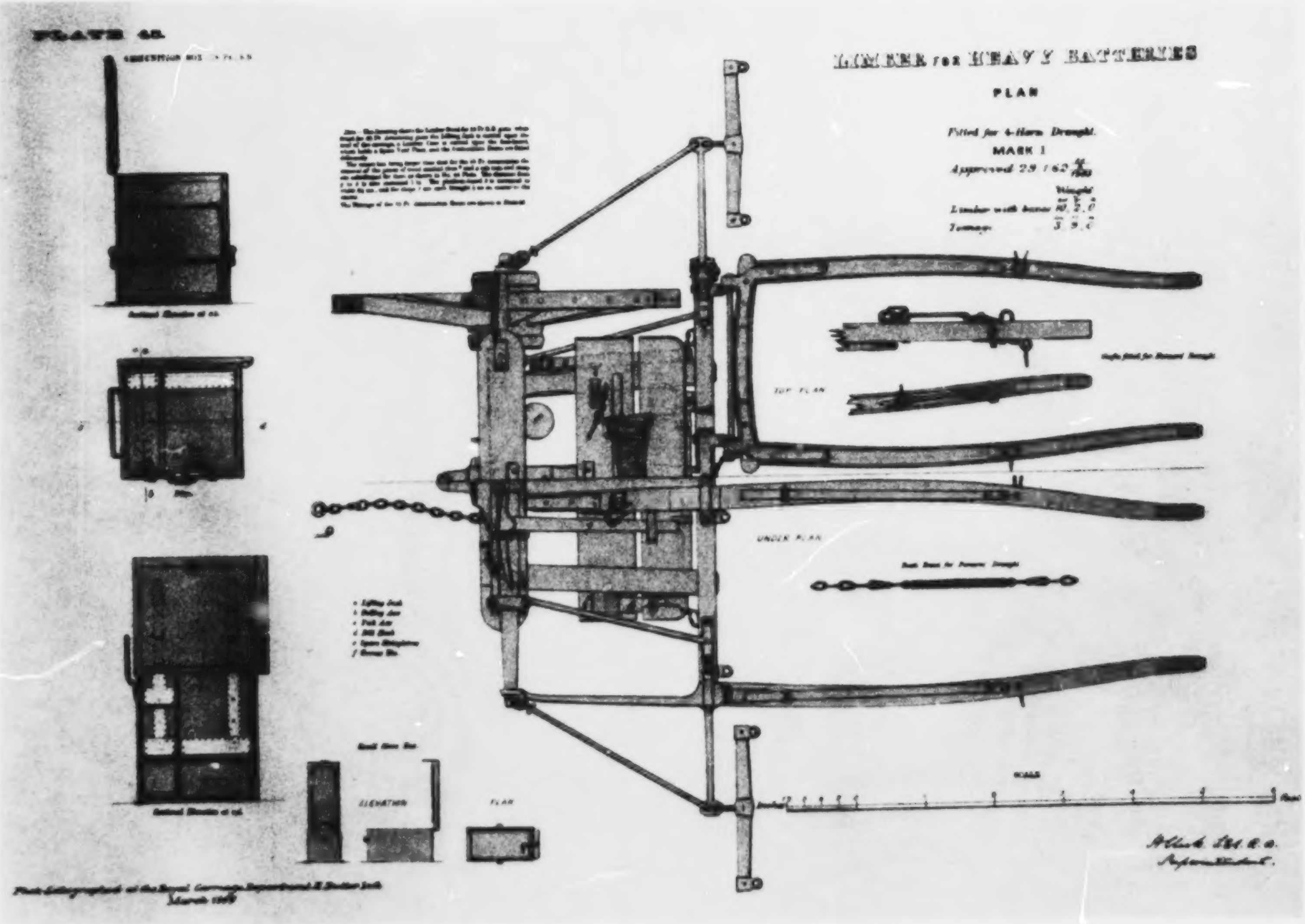


PLATE 45.
LIMBER FOR HEAVY BATTERIES
PLAN
Fitted for 4-Horse Draught.
MARK I
Approved 29.1.62
Weight
Limber with boxes
Tonnage
TOP PLAN
UNDER PLAN
ELEVATION
PLAN
SCALE

Figure 179. Limber for Heavy Batteries. Plan. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 45, March 1869.)

GUN SLEIGHS

While it is likely that in North America during the winter months sleighs were used to convey guns in the same manner as other goods and materials, it was not until 1760 that the Royal Artillery designed sleighs from which a gun or howitzer could be fired.

> During the late War in America the Seven Years War , it was found very inconvenient in the Winter to transport Guns and Howitzes [sic] over the Snow on their own Carriages made with wheels, Slade [sic] were therefore made at Quebec for light six pounders and Royal Howitzers....[1]

This simply constructed sleigh consisted of two wooden runners, sheeted on the bottom with iron, connected at one end by a heavy wooden transom and toward the other by a vertical framework, somewhat like a sawhorse, upon which the axletree of the carriage was strapped by metal bands. The bottom ends of the double bracket trail, which rested in two slots cut into the heavy transom, were held in place by an iron bolt passing through the transom and pintle hole. The sleigh was pulled by two horses abreast, harnessed to a central pole hooked to the heavy transom (Fig. 180).[2]

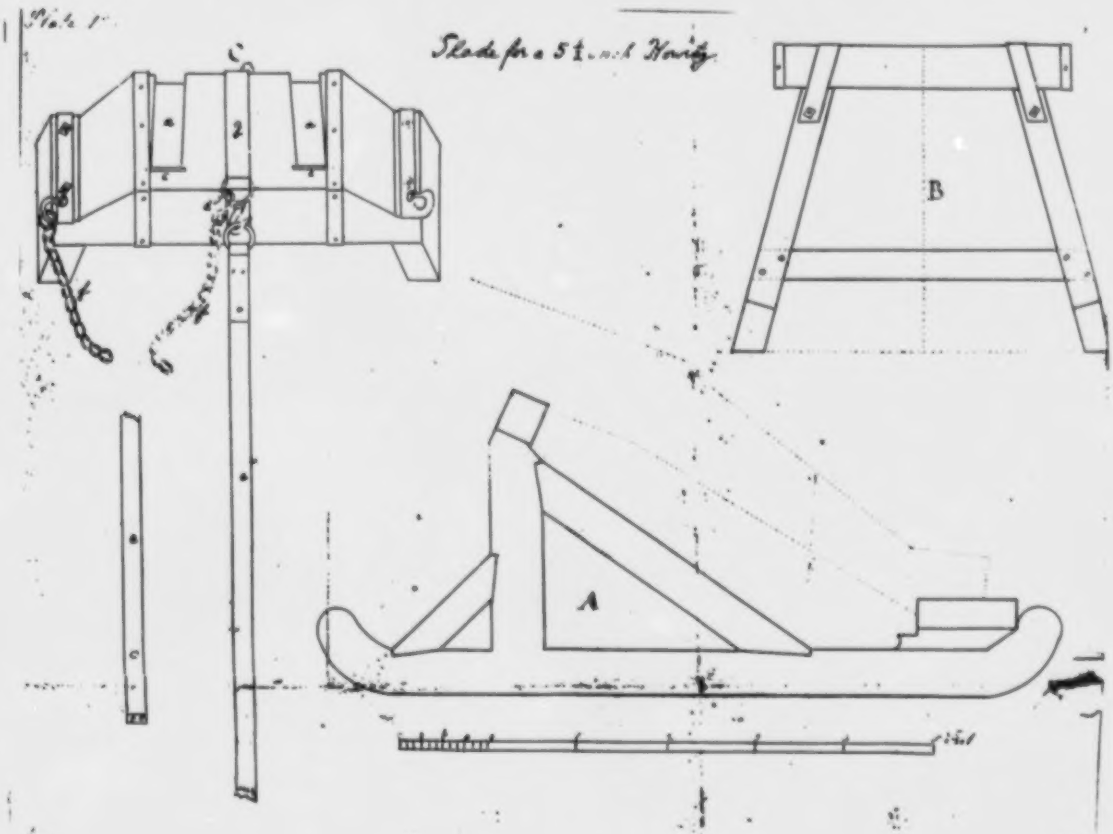


Figure 180. Slade [sic] for a 5 1/2 Inch Howitz [sic]. (The Royal Artillery Institution, Woolwich, U.K., Adye (1766), Plate 12.)

Captain John Knox, who kept a journal during the winter of 1759-60 at Quebec, noted that, around the middle of January 1760, "Our artificers are constructing sleigh carriages for the service of cohorns [sic], and guns of six and twelve pounders." Early in February, he wrote,

> A six and twelve pounder were mounted on distinct sleighs, when trial was made of them, and the invention answered to our most sanguine wishes, being drawn and worked with as great facility, as upon wheeled carriages.

Since the French did not attack until April when the snow had melted away in many places, the sleigh carriages proved of little use.[3] Probably, the sleighs that Knox referred to were similar to that drawn in Adye's notebook six years later.

Although eighteenth-century armies rarely mounted major campaigns in winter, the need for sleighs to transport ordnance for minor forays or to support foraging parties was obvious.[4] Even though there seems to have been no standardized design emerging out of the experience in Canada in 1760, there are a number of references to the use of sleighs by the British forces during the American Revolutionary War, both in Canada and at New York. They seem to have been of two kinds – the travelling or field carriage, the wheels removed, mounted on a sleigh; and a specially designed carriage, similar to a garrison carriage, mounted on runners.

Adrian Caruana in his article "Artillery Sledges & Gun Sleighs in North America, 1778-1783" has documented a number of instances of the use of gun sleighs in Canada and at New York. He argued that one type of sleigh probably mounted the field carriage on runners and, lacking a description from the 1770s, he speculated as to the nature of the sleigh. He cited an illustration from the circa 1820 notebook of John Cockburn, a student at the Royal Military Academy, as a probable example of the design of a sleigh for a field piece during the Revolutionary War. In the drawing the axletree arms of the carriage were attached by capsquares to a wooden frame on runners, with the unsupported trail of the carriage dragging behind. Caruana's conclusion may be correct and some form of this sleigh may have been used in the 1770s, but it is equally reasonable to assume that some variation of the earlier Quebec sleigh was adopted.[5] Also, there is evidence that the type of carriage drawn in the Cockburn notebook was not introduced until 1813 (see below).

Caruana also argued that some form of sleigh resembling a garrison carriage resting on a flat platform mounted on runners was used as well. He based this conclusion on references in the documents to carriages "with beds and coins on sleds," which are suggestive of other than field carriages. An artillery officer writing in 1858 supported this view:

> ... that first sleigh used consisted of two brackets for the gun to rest on, placed on the simplest form of sledge. The platform of this Sleigh was about 8 inches from the ground, and was inclined a little upwards at each end; the runners (or part resting on the ground, in fact the substitute for wheels) were placed at about 27 inches apart, that being the usual breadth of the traineaux used by the French Canadians, and consequently of the winter roads in Lower Canada at the time these Sleighs were introduced into the service.[6]

While this officer's evidence must be treated as critically as any other secondary source, presumably he was working with documents no longer available.

In 1796, a garrison carriage type of sleigh was constructed and tested at Quebec; according to Ralph Willet Adye, compiler of Little Bombardier and Pocket Gunner, it performed very well (Fig. 181). His description of it is worth quoting in full:

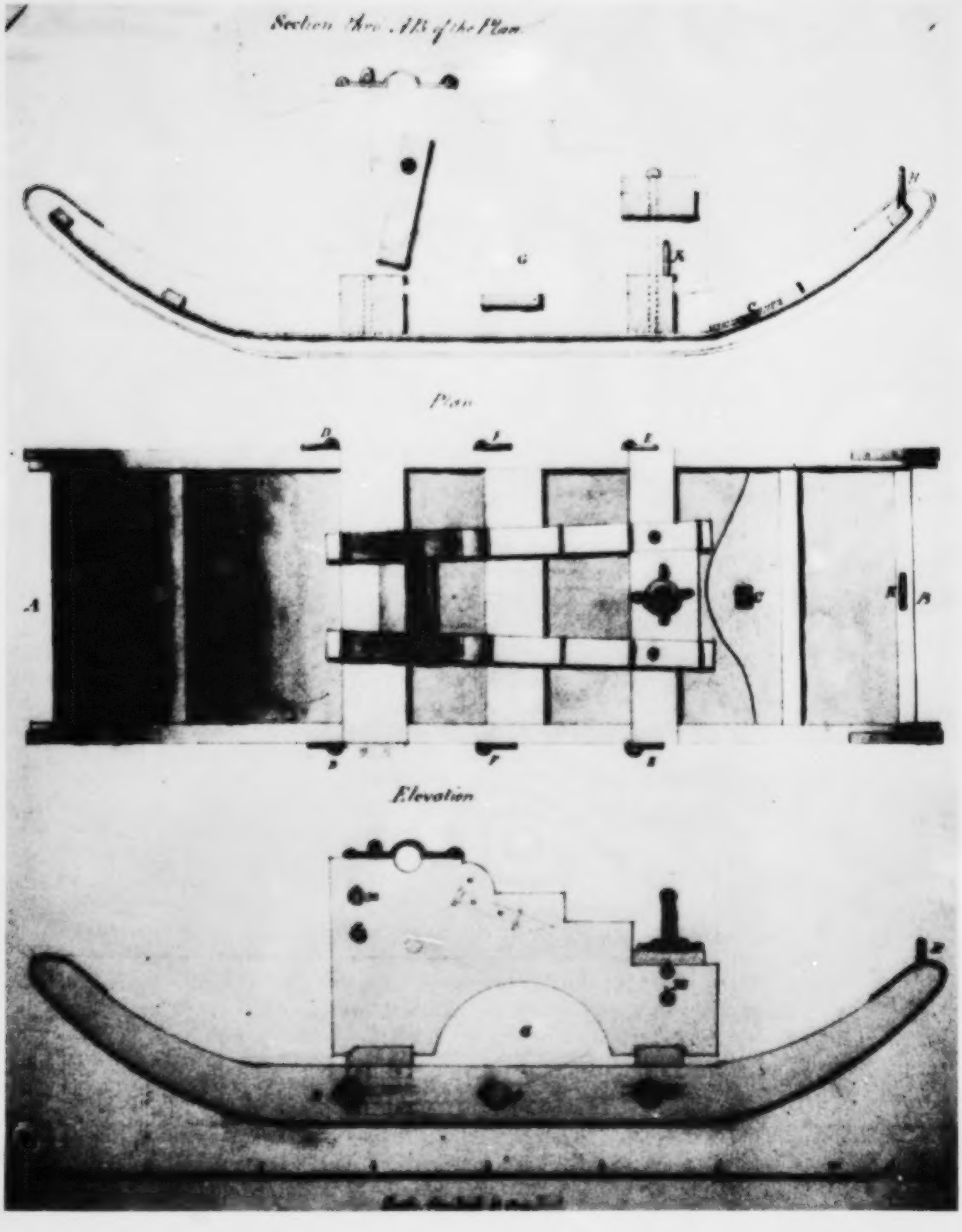

Section thro' AB of the Plan
H
G
K
Plan
D
E
E
A
B
D
F
E
Elevation
G

Figure 181. Section, Plan, and Elevation of a Gun Sleigh. (Parks, Fort Malden National Historic Park, Adye, Notebook, circa 1800.)

> This Slay [sic] was made and tried at Quebec is 1796 — It is drawn by Horses on a lead, by means of Shafts fixed at C, or by men on SnowShoes, with two pair of Drag Ropes — The front ones fixed to the Rings D if advancing and to E if retreating; the rear ones being hooked to the center rings F either in advancing or retreating — This Gun was drawn and worked by 15 Men on SnowShoes with great ease and expedition, and kept up with a column of Infantry, likewise on SnowShoes — Several discharges were made from it by way of Experiment, with round Shot and Grape, which it stood without injury — It recoiled generally about 7 feet in Soft Snow — A Box was fitted to the Space G, which held 14 rounds of Ammunition — This Box was Semi-circular at top, was in length, the breadth of the Slay, and having a handle at each end, was easily removed and placed in the rear, when the Gun was prepared for Action — A crooked handspike passed thro' the ring H and was keyed under the Staple K; by this it was traversed — The side Arms were lashed on by means of the small ring M.[7]

Even though, according to Adye, the sleigh had performed well, it had several shortcomings. In a memorandum on gun sleighs, Lieutenant-Colonel William Robe, R.A., analysed the defects of the light 6-pounder sleigh in use in Canada in 1800:

> the principle of the Carriage is defective from being on a Garrison Pattern, the wood of the Cheeks being so much cut away, as well by the steps, as by the segment for the [ammunition] box, leaves very little grain of the wood to resist the shock of the Recoil.

Then, interestingly, he recommended a reform:

> For this reason the principle of the Travelling Carriage appeared to me more Eligible, taking the straight grain of the wood & supporting it on a frame as in N^{o}2, a few were constructed nearly on this Principle, only the front supporting Transom was a solid piece instead of a frame.[8]

Unfortunately. the drawings accompanying the memorandum have not been discovered, but clearly some adaptation of a travelling or field carriage to a sleigh was contemplated.

The problems of a garrison carriage sleigh were even more extensive that Robe had stated.

> The principal objections to this Sleigh were that it soon got injured in travelling, particularly when passing over uneven roads, from the transoms which connected the runners coming in contact with large lumps of ice, snow, & c., arising from their being only raised about 4 inches from the ground; and that the gun was not sufficiently raised to permit of its being readily laid, notwithstanding which it was much too easily overturned when travelling.[9]

About 1813, Major John S. Sinclair, R.A., designed a new pattern sleigh which overcame these problems, except that of overturning.

> In this Sleigh the summer carriage, having the axle-tree [sic ?] and wheels removed, was placed with the axle-tree bed resting upon runners about 16 inches high, the trail resting on the ground and being to the rear in travelling.[10]

This description fits the Cockburn drawing, circa 1820, cited by Caruana, which,

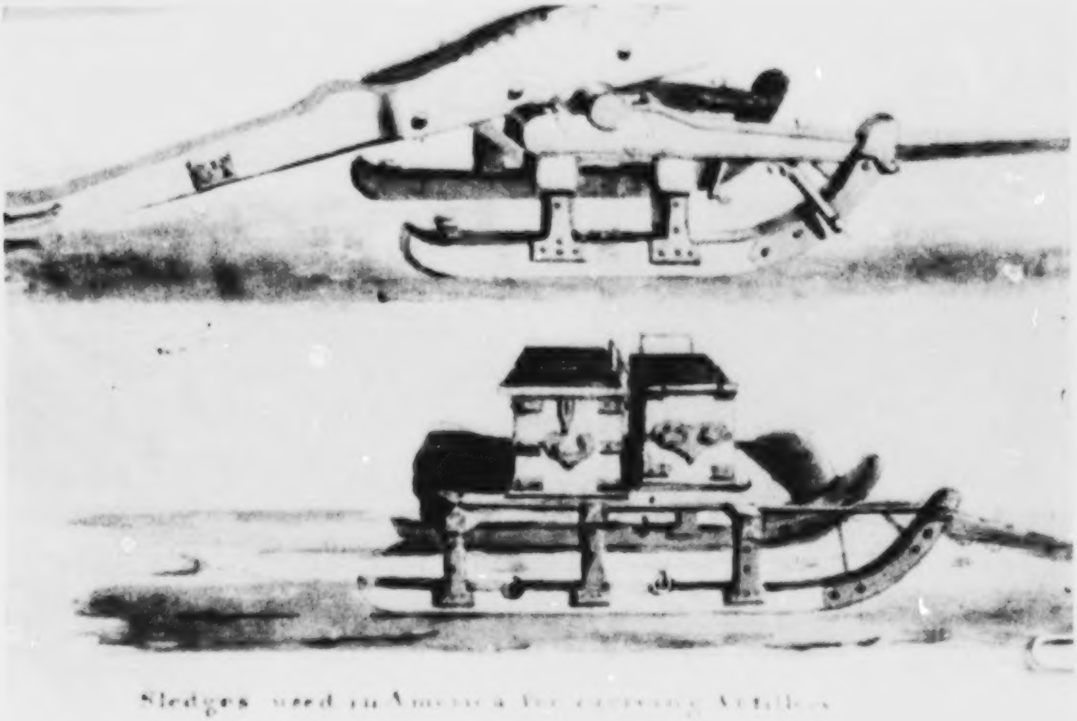

Sledges used in America for carrying Artillery

Figure 182. Gun and Ammunition Sleighs. (The Royal Artillery Institution, Woolwich, U.K., Cockburn, "Notes on Artillery," circa 1820.)

consequently, can be reasonably described as a Sinclair pattern gun sleigh (Fig. 182).[11]

Despite the improvement, objections to the new sleigh resulted in a model of it being sent from Canada to Woolwich, about 1829 or 1830, to be examined by a committee of artillery officers. They rejected it and proposed a new pattern, subsequently adopted, called the "Woolwich Pattern."

> This sleigh is much superior.... Although high enough to permit of the gun being laid with tolerable facility, it travels well over the worst roads with the muzzle either to the front or rear....
>
> The Woolwich Pattern consists of a platform 6 feet 10 inches long, and 3 feet 10 inches wide, placed on runners 16 inches high, upon which rest two strong transoms to which the brackets supporting the gun are secured. A box is placed on each side of the gun, together capable of containing about thirty rounds of ammunition, and which serve as seats for Nos. 1 and 2....
>
> The extreme breadth of the runners is three feet, which through broader than the Sleighs used by "the habitans" of Lower Canada, is not so broad as to prevent their travelling over any of the ordinary roads of the country.[12]

This description was written in 1858, but it seems probable that few if any changes had been made in the carriage since its introduction in the 1830s (Fig. 183).

Accompanying the gun sleigh were ammunition sleighs. The early documents do not mention them specifically; they may have been especially designed, or the common sleighs of the country may have been used. Cockburn's drawing, circa 1820, depicted an ammunition sleigh, a simple platform on runners to accommodate the ammunition boxes.[13] When the Woolwich Pattern sleigh was adopted, an ammunition sleigh was also accepted, which seems to have been the basic platform of the gun sleigh with whatever minor modifications were necessary to accommodate the boxes and other stores necessary to the working of the gun.[14]

The Woolwich Pattern sleighs were built by contractors in Canada:

> Sleighs have hitherto been built by contract, the price being 13 l. to 14 l. sterling for the Gun Sleigh, and 10 l. to 11 l. for each Ammunition Sleigh. The timber used was American, which is inferior to that of this country England . They should be made of English oak, with the exception of the shafts, splinter bars, and platforms, the two former of ash, the latter of fir. If made in the Storekeeper's Department at Montreal, uniformity of construction, good materials, and the best workmanship would be ensured.[15]

It is not known if the Ordnance continued to contract out the manufacture of the sleighs or not.

Fig. I. *Gun Sleigh.*

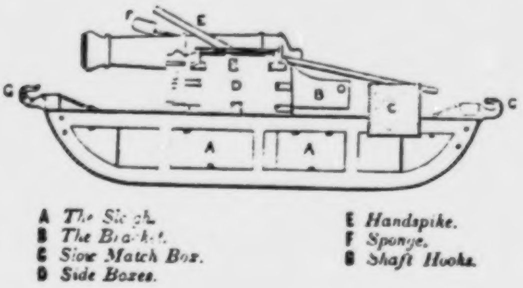

F
E
C
D
B
G
C
G
A
A
A The Sleigh.
B The Bracket.
C Slow Match Box.
D Side Boxes.
E Handspike.
F Sponge.
G Shaft Hooks.

Fig. II. *Ammunition Sleigh.*

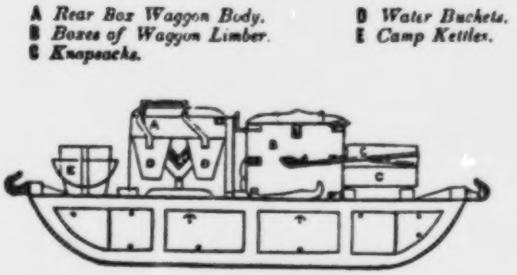

A Rear Box Waggon Body.
B Boxes of Waggon Limber.
C Knapsacks.
D Water Buckets.
E Camp Kettles.
A
B
C
D
E

Figure 183. Gun and Ammunition Sleighs, circa 1860. (Great Britain. War Office. Manual of Field Artillery Exercises (London: H.M.S.O., 1861), opposite p. 181.)

TRAVERSING PLATFORMS

Common Traversing Platform

In 1793, Lieutenant John Rutherford, R. E., designed and erected on the Scilly Islands at least one, perhaps two, wooden traversing platforms for a 24-pounder iron gun.[1] The rough sketch and explanation which he sent to the Royal Military Repository, Woolwich, in July of that year are the earliest records yet discovered of this innovative method of mounting ordnance (Figs. 184a and 184b).[2] The platform, which supported a gun on a standing garrison carriage, was a rectangular frame 14 feet long and 3 feet 5 inches wide. According to Rutherford's note:

> The principal pieces [were] 6 inches square — 2 1/2 inch plank [was] nailed on the inside... to keep the gun from running to one side — and 2 1/2 inch plank [was] nailed on the top where the trucks run 9 inches wide —[3]

The final 3 feet of the side pieces rose rather abruptly, presumably to act as a brake on the carriage as it recoiled.

To enable the gun to fire over the parapet, the platform was supported on what appear to have been two raised masonry abutments, a massive one at the front and a slighter one at the rear. It was held in place by a pintle, around which it rotated, which was fixed into the fore abutment and inserted into a wooden transom set into the side pieces about 2-1/4 feet from their front edges. At the front, it rested entirely on the pintle, fore trucks not being evident. At the rear it rotated on a single wheel, probably of iron, 1-1/2 feet in diameter, which was fixed on an axle mounted between two transoms. A large ship's wheel was attached to a rear-extension of the axle; its rotation turned the smaller wheel, thereby traversing the platform. (Rutherford noted that originally he had used a windlass). Although the

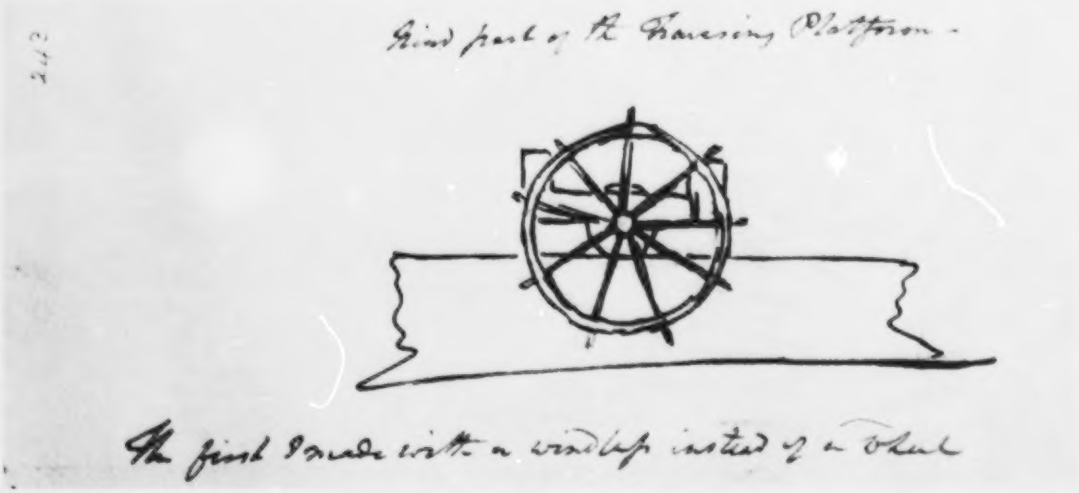

Hind part of the Traversing Platform -
The first I made with a windlass instead of a wheel

Figure 184a. Hind part of the Traversing Platform executed at the Scilly Islands in 1793. (The Royal Artillery Institution, Woolwich, U.K., "Collected Military Papers," Vol. 2.)

drawing does not show it, possibly the smaller wheel moved on a track of wood or iron.

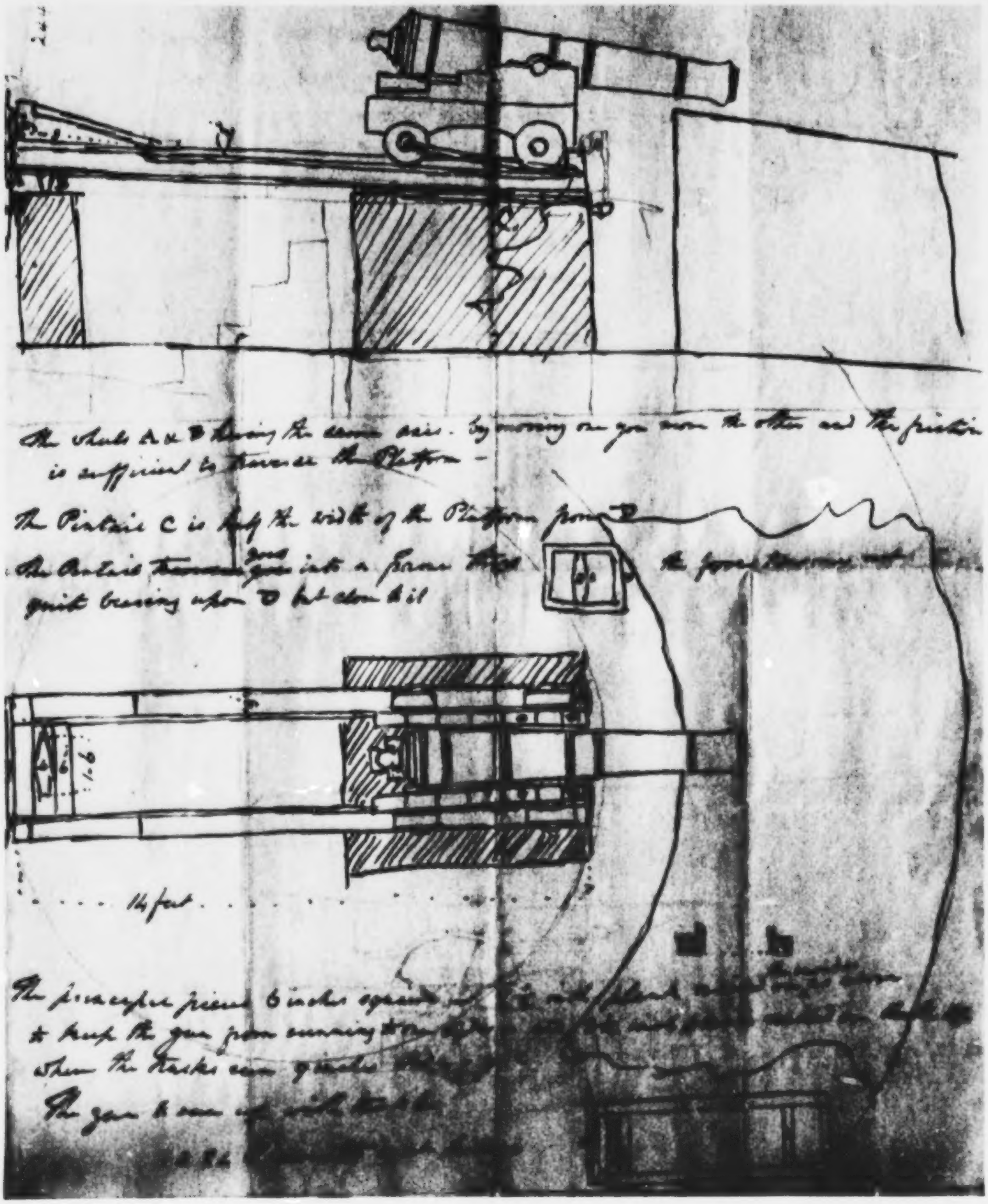

The wheels A & B having the same axis. by moving one you move the other and the friction
is sufficient to traverse the Platform –
The Pintle C is half the width of the Platform from D
The Pintle [illegible] goes into a frame [illegible] the frame [illegible]
quit bearing upon D but close to it
14 feet
The preventer piece 6 inches square [illegible]
to keep the gun from running [illegible]
when the trucks are [illegible]
The gun [illegible]

Figure 184b. Sketch of a Traversing Platform executed at the Scilly Islands in 1793. (The Royal Artillery Institution, Woolwich, U.K., "Collected Military Papers," Vol. 2.)

Traversing platforms very similar to Rutherford's were built for the defence of Halifax in the 1790s. In 1801, George Parkyns, an English landscape painter, published an engraving of "View of Halifax from George's Island," showing in the foreground a battery of six guns mounted on traversing platforms which, except that the ship's wheel was lacking, were clearly relations of Rutherford's platforms (Fig. 185).[4] They had been in place there since at least 1795. In August of that year, Prince Edward, commander-in-chief, Nova Scotia and New Brunswick, directed:

> that the Traversing Carriages [platforms] making for the Battery at Point Sandwich, should have but One Wheel in the Centre, similar in every respect to those on Georges [sic] Island and Fort Ogilvie, and further to direct that those already at Point Sandwich should be altered as soon as the remainder are finished.

Slightly less than a year later, he gave orders:

> to fit iron circles for the wheels of the Traversing Carriages [sic] to move upon at Point Sandwich .
>
> His Royal Highness further directs... that the Traversing Carriages [sic] for the twelve pounders at that post should be altered to have only one wheel behind, like those on Georges [sic] Island.[5]

Obviously, a platform slightly different than that shown by Parkyns had been put up at Point Sandwich. Is it possible that the alteration "... to have only one wheel..." meant that the large ship's wheel of Rutherford's design was being removed? The platforms shown by Parkyns where probably traversed with handspikes.

A scaled drawing of a traversing platform for a 12-pounder gun, which bears a close resemblance to those Parkyns depicted, has been discovered in a notebook, circa 1800, attributed to R.W. Adye, the compiler of Bombardier and Pocket Gunner (Fig. 186). Although it is, of course, impossible to compare in detail the drawing with the platforms in the Parkyns engraving, it can be compared with the Rutherford drawing of 1793, of which it appears to be a stronger, more sophisticated version. The side pieces were 14 feet long, but they were wider and thicker, 8 or 9 inches by 12 inches. There was no indication of soles nailed on top of them; rather runners, about 2-1/2 inches square, were attached to their upper surfaces to keep the trucks of the gun carriage running true. The platform was wider, 3 feet 8 or 9 inches, which would be consistent with wider side pieces. The pintle appears to have been a long bolt penetrating through the centre of the front transom into a pintle block. This transom was yoke shaped and was bolted vertically to the side pieces. The traversing wheel, which was 1 foot 9 inches in diameter (slightly larger than that shown by Rutherford), was held in place by two brackets bolted underneath the rear transoms. These were tenoned into the side pieces, and the rearmost was bolted tightly into place. Since there was no indication of a ship's wheel, presumably the platform was traversed by handspikes or by tackle.[6]

Of interest is another drawing, circa 1812, which shows a more sophisticated traversing platform (Fig. 187).[7] It was signed by A. Gray, who has not been positively identified, and it is not clear if it was a drawing of an existing platform or if it was merely a proposal. Like Rutherford's, it was without legs and rotated on a front pivot. Unlike his, the front was supported by two small trucks, about 5 inches in diameter, running on a small circular track; the rear similarly moved on two trucks (not one), about 18 inches in diameter, also running on a track.

Of particular note in this drawing is what appears to be a carriage restraining device. Attached to the rear axletree (the method is not clear but it had to allow for vertical movement) was a piece of flat iron about 3 feet long, slightly curved, with a tooth at one end. This piece of iron rested in a groove cut into a squared timber

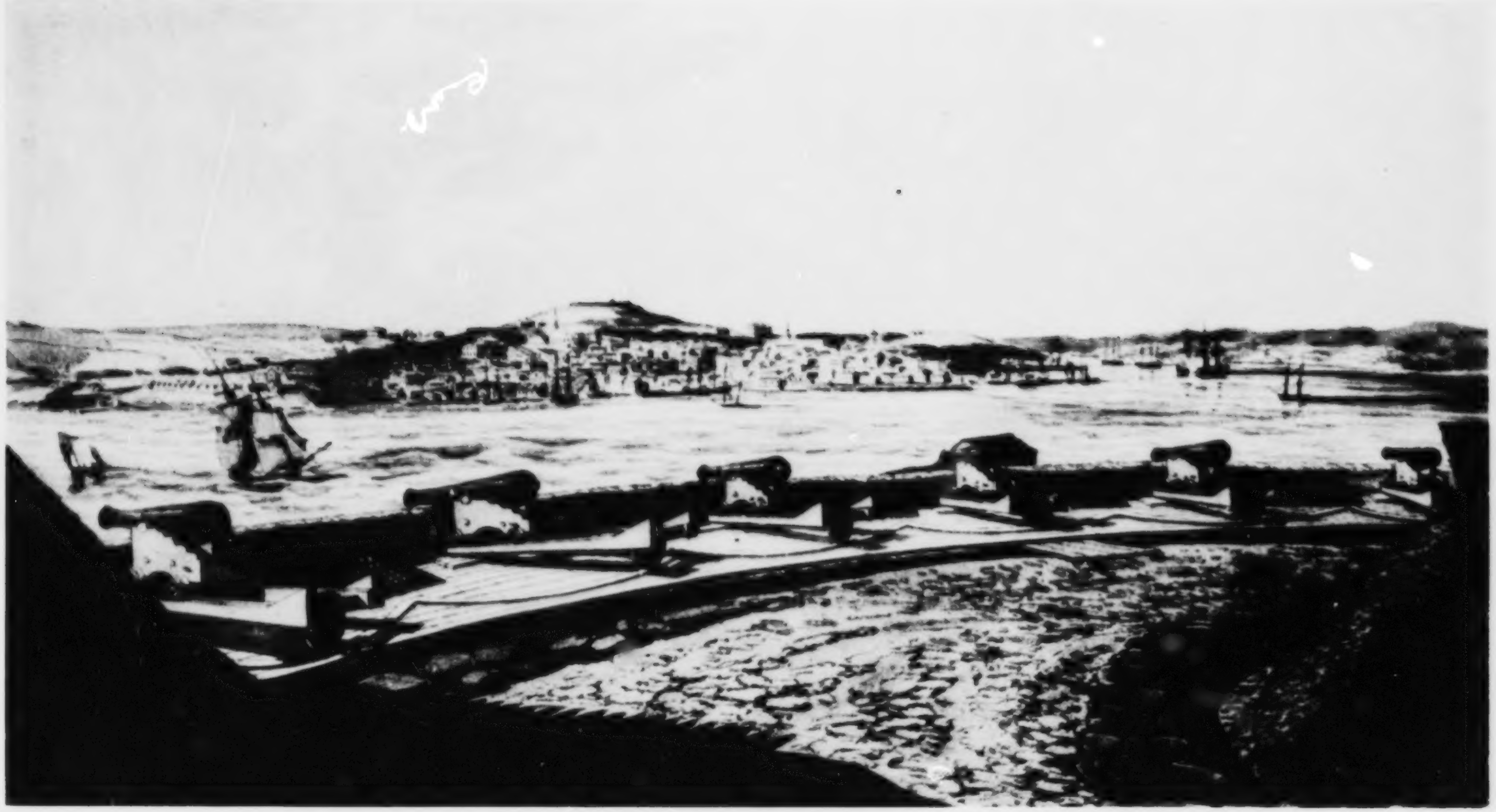


Figure 185. View of Halifax from Georges Island, by G.I. Parkyns, circa 1801. (National Archives of Canada, C-982.)

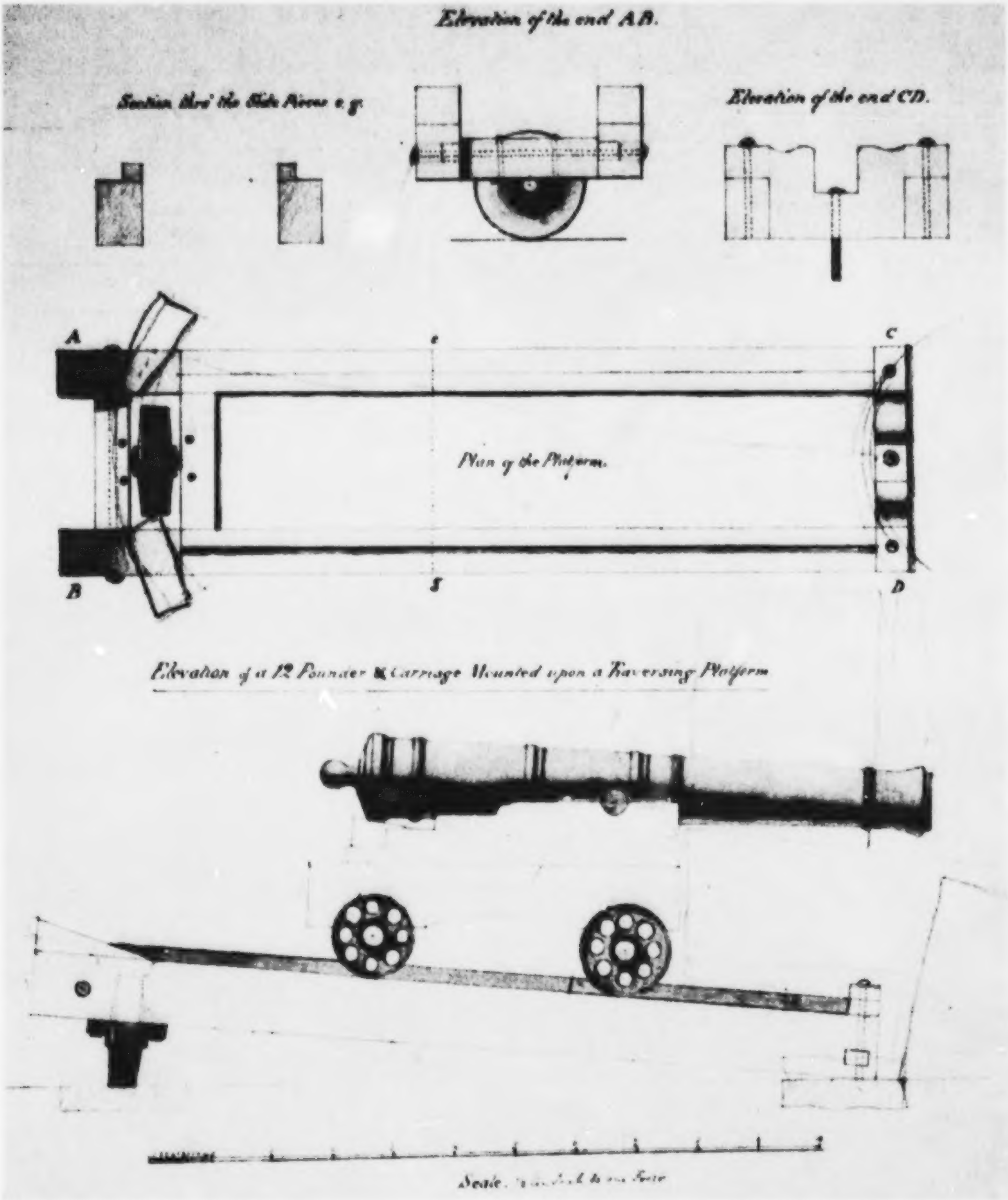

Elevation of the end AB.
Section thro' the Side Pieces e.g.
Elevation of the end CD.
A
e
C
Plan of the Platform.
B
f
D
Elevation of a 12 Pounder & Carriage Mounted upon a Traversing Platform
Scale

Figure 186. 12 Pounder & Carriage Mounted upon a Traversing Platform. (Parks, Fort Malden National Historic Park, Adye, Notebook, circa 1800.)

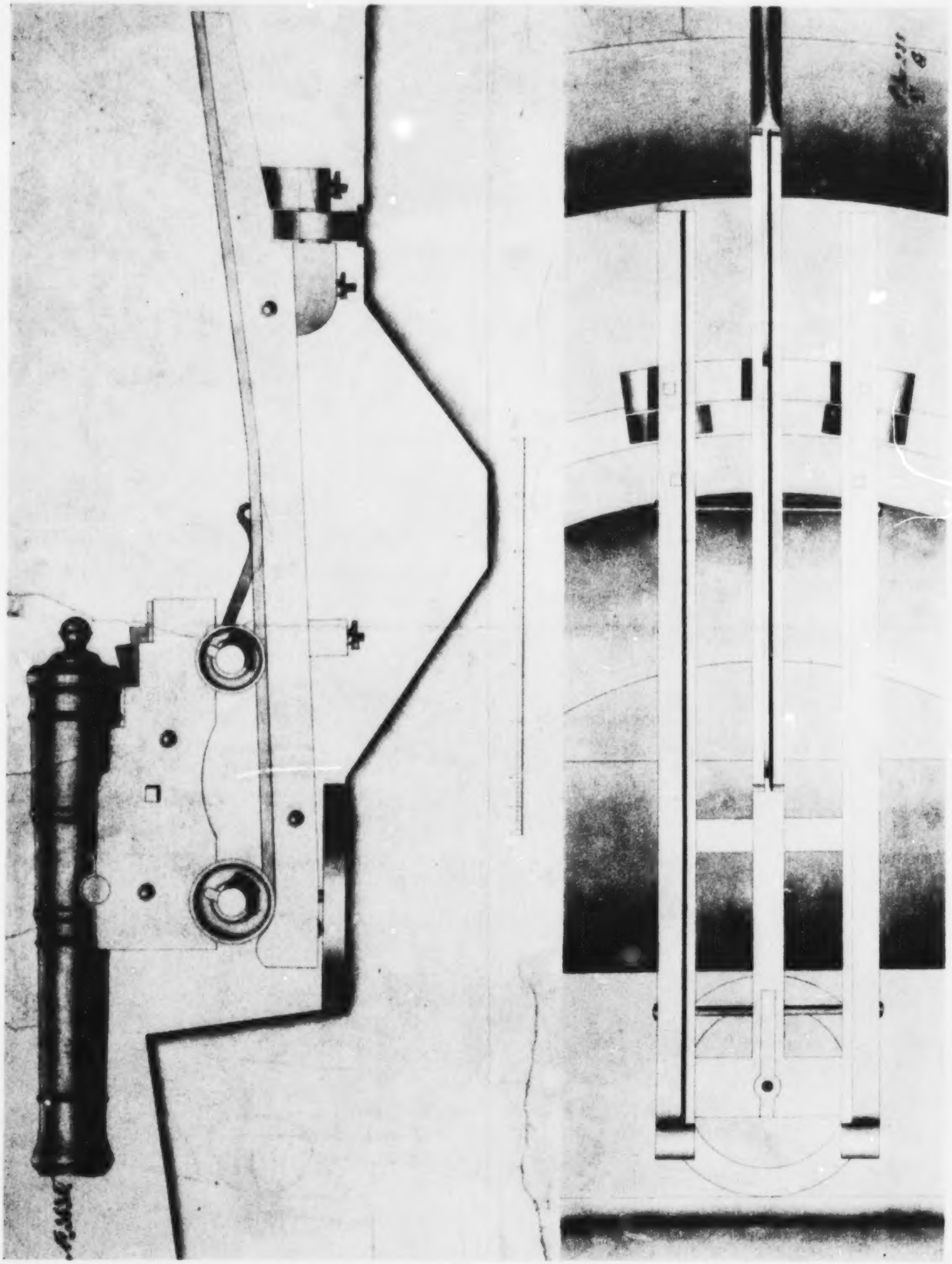


Figure 187. Detailed drawing of a gun on traversing platform and emplacement, by A. Gray, circa 1812. (National Archives of Canada, C-5549.)

which ran down the middle of the platform. In the groove were two notches which would receive the tooth. Thus after the gun had recoiled up the sloped side pieces it was restrained from running forward again by the tooth hooking into the rear notch. Similarly when it was run forward it was again restrained by the tooth hooking into the front notch. It is unknown whether this design was ever tested.

During the 1790s, traversing platforms of other designs also came into use, but their advantages were in dispute between officers of the Royal Artillery and of the Royal Engineers. In 1804, following a complaint about some platforms in use in the Southern District in England, the Inspector-General of Fortifications, Lieutenant-General Robert Morse, proposed to the Master-General, the Earl of Chatham, that a committee made up of officers from both corps be convened to consider the problem. The terms of reference which he suggested were:

> 1st Whether Traversing Platforms are generally or in what particular cases preferable to the common Stone or Wooden Platform combining [?] the consideration of firing through Embrazures [sic] or over the Parapet
>
> 2nd For what height of Parapet in the latter case should the Traversing Platform be constructed.
>
> 3rd Whether the Center of motion should be near the front or near the rear or towards the center of the Platform and for what reason.
>
> 4th What should be the length of the traversing Platform and the inclination of the Plane to govern the recoil and the number of its Trucks –

In Morse's opinion, it was desirable to arrive at a standard so that the platforms "... may be made by Contract and kept in Store ready to deliver when wanted...."[8] No record of such a committee or of its deliberations has been found, but it seems likely that it met and determined standards for the traversing platform.

Although no details have been found, three traversing platforms, to be mounted on front, centre, and rear pivots, were sent to Quebec "to serve as Patterns...."[9] Also, by 1813, Adye had added to his manual a short section on traversing platforms which answered the questions raised by Morse.

> That adapted for general service in this country, is 16 feet long, traversing on 4 iron trucks. The length of the transoms, or distance between the side pieces must depend upon the nature of ordnance intended to be mounted on it; for a 24-pounder the distance is 2 feet 7 inches. The width of the side-pieces are generally 10 inches, and the depth 11 inches, to which is added a 2 inch board on the upper part for the trucks of the gun carriage to recoil on. The height of the traversing platform in regulated according to the height of the parapet, usually allowing 6 inches from the under part of the gun to the top of the parapet. The slope on which the gun recoils is 1 inch to a foot. The pivot on which the platform traverses, is placed in the front[,] centre, or rear transom; in batteries liable to be attacked in the rear, it would be advisable to place the pivot in such a manner, that the gun may be brought round to defend the gorge of the work.[9]

For about the next 30 to 40 years, the platform described by Adye was in common use in Canada. There is evidence of its being mounted in Prince of Wales tower at Halifax in 1812, at Côteau du lac in 1821, at Quebec City in 1836, at the Eastern Battery, Halifax, in 1839, and in Fort Henry, Kingston, in 1851 (Figs. 188 and 189).[11] Details of repairs at Fort Wellington in the late 1840s indicate that there may have been local variations in certain dimensions; the side pieces were said to be 16 feet long but 8 inches wide and 9 inches thick.[12] But essentially it remained the same. Scaled diagrams by Shuttleworth in 1819 (Fig. 190) and in the Aide-Mémoire in 1846 show little if any change except that the slope was slightly gentler, 7/8 inch in 12 inches.[13] Certain details, which were always present, also emerged — a grate between the centre and rear transoms on which the gunner stood to lay the gun, foot boards at the side and rear, blocks at the ends of the soles against which the trucks could come to rest as the gun recoiled or was run out.[14]

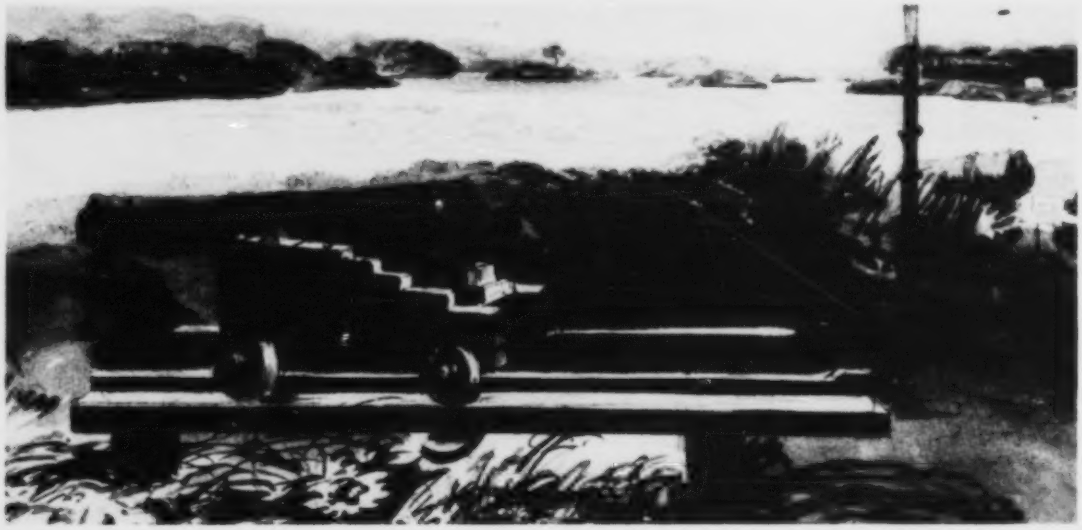


Figure 188. The Coteau Rapids from the Fort, 1821, by John Elliott Woolford. (National Archives of Canada, C-99548.)

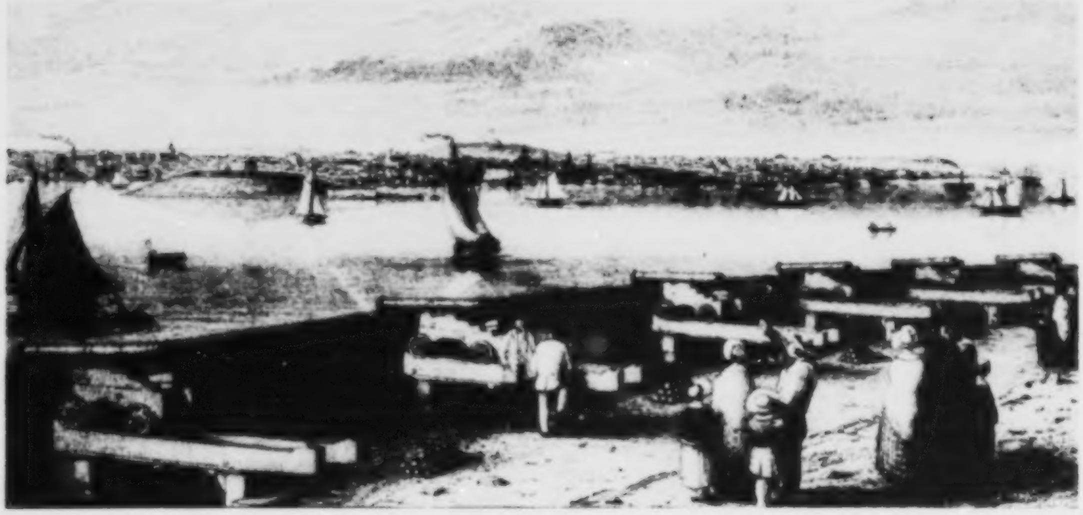


Figure 189. Halifax from the Eastern Battery, by J.S. Clow, circa 1839. (National Archives of Canada, C-94689.)

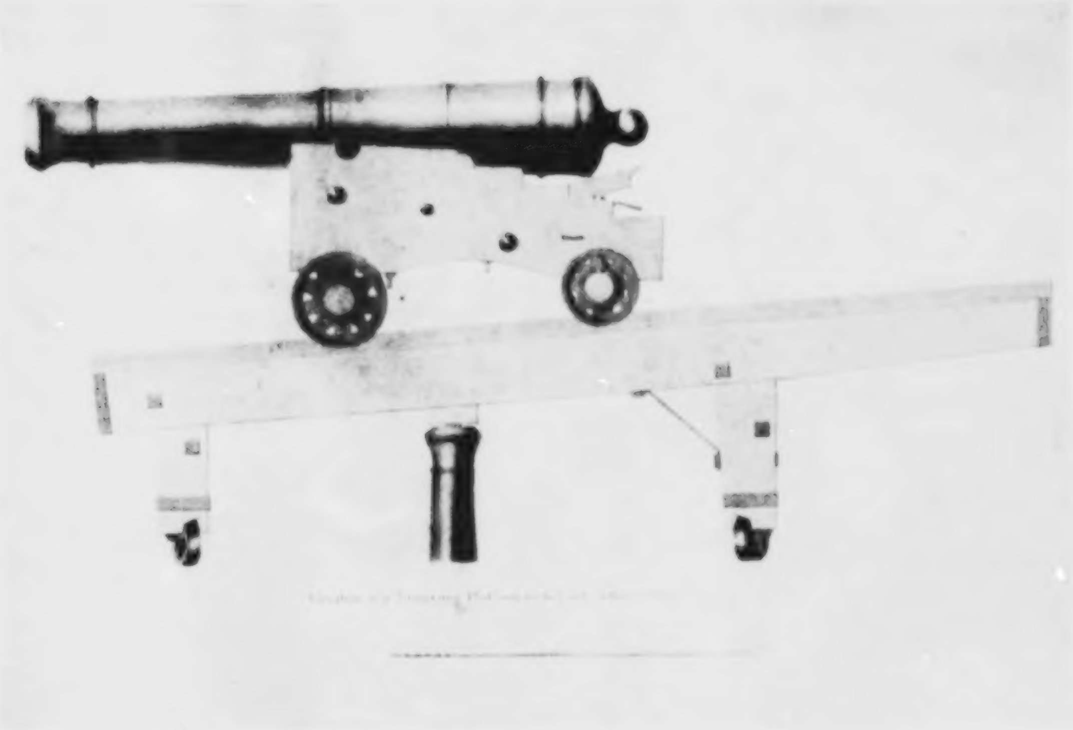


Figure 190. Elevation of a Traversing Platform with Pivot in the Centre, 1819. (The Royal Artillery Institution, Woolwich, U.K., Shuttleworth Drawings.)

In 1846, the Aide-Mémoire implied that handspikes alone were used to work the traversing platform and that the blocks and tackles formerly used had been done away with. A memorandum by "an old Artillery Officer" was very critical of the new method and the diagram in the Aide-Mémoire included ring bolts "... on the ends of the platform as originally constructed."[15] In 1819, Shuttleworth did not show them, but a drawing in a notebook of 1830 depicted blocks and tackle draped over the ends of a traversing platform (Fig. 191). Clow's drawing of the Eastern Battery at Halifax in 1839 clearly indicated the eye bolts, although blocks and tackle were not evident.[16] It may be that blocks and tackle were more common than the Aide-Mémoire implied. Certainly the old artillery officer did not regard the use of hand spikes as an improvement: "... much of the efficiency of the platform itself, as to accurate and rapid firing at a ship in motion has been lost" [italics in original].[17]

By the 1840s, the common traversing platform was falling into disfavour, being replaced by the dwarf platform. In January 1853, the Master-General and Board approved a recommendation to discontinue it in favour of the latter.[18] The advantage of being able to fire over a parapet through a wide angle was outweighed by certain disadvantages. The gun and carriage mounted on the common traversing platform presented a large target above the parapet and could be easily dismounted. Their height made mounting the guns more difficult. The gunners working the guns were very much exposed. Also, as the guns became heavier, it was felt that the long-legged platform was a weaker construction.[19] Undoubtedly, the common platform continued to be used, for it was still being described in the 1860s. The only major change it seems to have undergone was an increase in the thickness of the side pieces to 14 inches; the width remained at 10 inches.[20] This increase was probably a reaction to the heavier guns being mounted on it.

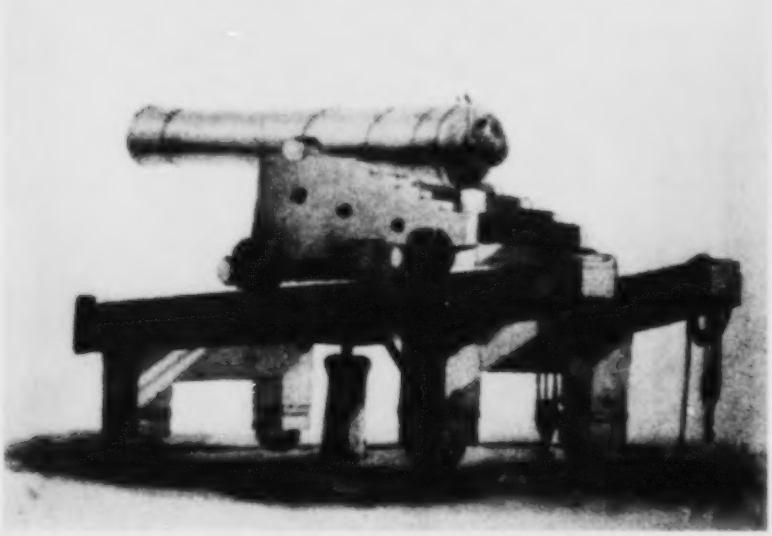


Figure 191. Common Traversing Platform, circa 1830. (The Royal Artillery Institution, Woolwich, U.K., Robert Cockburn, "Practical Course of Instruction.")

Dwarf Traversing Platform

In the early 1840s, Lieutenant-Colonel Anthony Emmett, R.E., designed the dwarf traversing platform, a low variation of the common traversing platform. Its similarity to the platforms built by Rutherford on the Scilly Islands and drawn by Parkyns at Halifax are evident (see above), but those early variants seem to have been supplanted by the long-legged platform. Although, in the Royal Navy, carronades had been mounted on slides since their inception, the dwarf's immediate ancestor, of which it was an adaptation, was the naval slide used to mount pivot guns on steamers.[21]

Emmett had removed the legs from the common platform and attached the trucks, mounted in flanges, directly onto its body. At the front they were bolted onto the side pieces and at the rear onto a block which passed underneath the side pieces, whereby a slope of 5 degrees was maintained. Since the carriage recoiled, not on trucks, but on blocks designed to be engaged between the side pieces, runners were no longer necessary to keep it on the platform. These blocks slid along wrought-iron soles which were the length of the side pieces but slightly narrower. Drawings in the 1840s indicated a wooden sole underneath the metal one, but later plans showed the metal sole fixed directly into the side pieces.[22]

The dwarf traversing platform was composed of two side pieces and three transoms held together by iron bolts. In order to prevent the carriage from dismounting at the front, a stop block was bolted between the side pieces, and at the rear two iron stops were attached to the insides of the side pieces. Sometime in the late 1840s a round bollard was set into the inner surface of the left side piece near its end. A restraining rope attached to the carriage was wound around it to control the spead of the carriage as it was run forward.

To aid the gunners in the working of the piece, footboards were attached to each side. Originally both may have extended from front to rear transom, but by about 1850, the left front board had been shortened to about half its former length. Generally, this was the nature of the dwarf traversing platform throughout the '40s, '50s, and '60s, although there were changes in detail, which can be seen on the accompanying illustrations (Figs. 192a and 192b).[23]

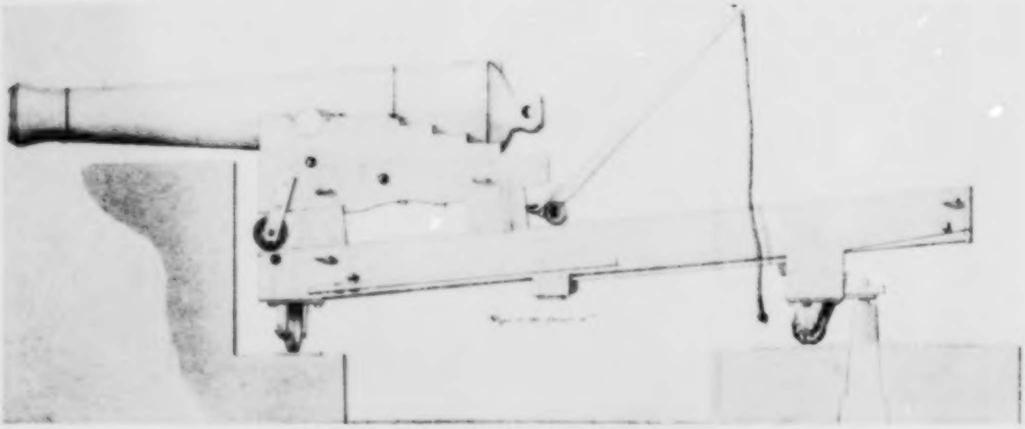


Figure 192a. 56 Pr. 11 ft. 98 cwt. on a Dwarf Traversing Platform, circa 1850. (The Royal Artillery Institution, Woolwich, U.K., Strange, "Drawings on Artillery.")

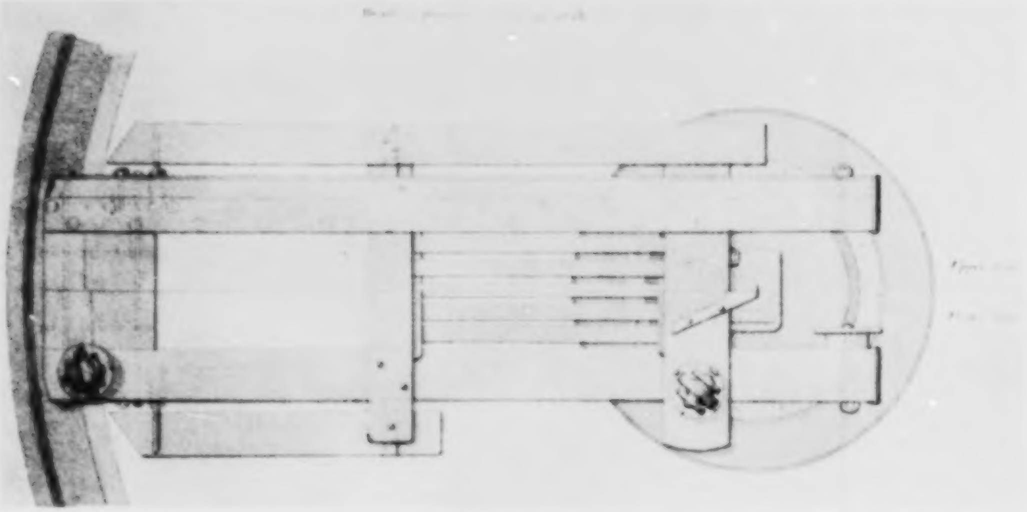


Figure 192b. Plan of Dwarf Traversing Platform, circa 1850. (The Royal Artillery Institution, Woolwich, U.K., Strange, "Drawings on Artillery.")

Since much of the evidence is lacking, it is difficult to trace in detail the changes over the three decades. The design published in the Aide-Mémoire in 1846 was adopted by an order of the Master General and Board of 1 April 1846; it was applicable to all calibres from the 8-inch gun down to the 18-pounder, except for the 56-pounder, the platform of which was slightly wider. Since this order superseded previous orders of 6 May 1844 and 15 December 1845, it is inferred that there were earlier designs, although no details have come to light.[24] These earlier versions may have been similar to that published by Straith in the Plates accompanying his manual of 1852.[25] The dimensions of this platform were different from those of the diagram in the Aide-Mémoire, principally in that it was longer, 16-1/2 feet, and the side pieces were thicker. The radii of the racers were also different. If Straith is correct, it seems likely that his design predated that of the Aide-Mémoire since designs in the 1850s and '60s more closely approximated the latter than the former.

According to the Aide-Mémoire, not only was the platform for a 56-pounder wider, 4 feet, but when mounted on a front pivot, it also had an intermediate set of trucks and racers, which were attached to the centre transom. This peculiarity of design was also indicated in a plan and section for a 56-pounder at Fort Henry, Kingston, Canada West, dated 24 July 1849, although the radii of the racers were different.[26] Undoubtedly, the third set of trucks and racers was thought necessary because of the weight of this gun, 97 or 98 hundredweight for the 11 foot model, but this development may have been short lived since there is a drawing of a dwarf platform for a 56-pounder, circa 1851, with only two sets.[27] There is no evidence, moreover, that the 68-pounder, an equally heavy gun, required additional trucks and racers.

The various weights of the platforms given by Griffith in his manuals during the 1850s suggest that probably there were minor changes made during the decade.[28] By 1860 there were two varieties of "Old Pattern" platforms, one for 68-pounders and 10-inch guns and one for all other varieties from 8-inch guns to 18-pounders.[29] These were superseded by a "New Pattern," adopted 29 May 1860, applicable to all natures of ordnance (Fig. 193). Subsequently, on 9 August 1864, another pattern with minor changes was approved (Fig. 194).[30]

Perhaps the major change in design was the removal of the pivot and the development of hollow-soled trucks to run on concave racers. The shock of the discharge of a gun had put a great deal of strain on the pivot, often loosening or breaking it, thereby rendering the platform unserviceable. To solve this problem Colonel James Nisbet Colquhoun, probably when he was Inspector at the Royal Carriage Department in the early 1850s, devised a system whereby the pivot was removed and the carriage was held in place by hollow-soled trucks fitted to concave racers. The racers were still curved but the gun rotated around an imaginary pivot, that is the point at which the pivot would have been, of which there were six positions, the choice of which depended on the nature of the gun position. Under this system when the gun was fired the shock of discharge was divided among four points and distributed over the racers, rather than being concentrated on the pivot.[31] It is not clear precisely when Colquhoun's improvements were accepted, but they were certainly in place by 1860.[32]

Previous to the adoption of Colquhoun's system there had been five positions of pivots with the corresponding sets of racers. The use of imaginary pivots allowed for a new position at the muzzle of the gun when it was run out and, therefore, a sixth

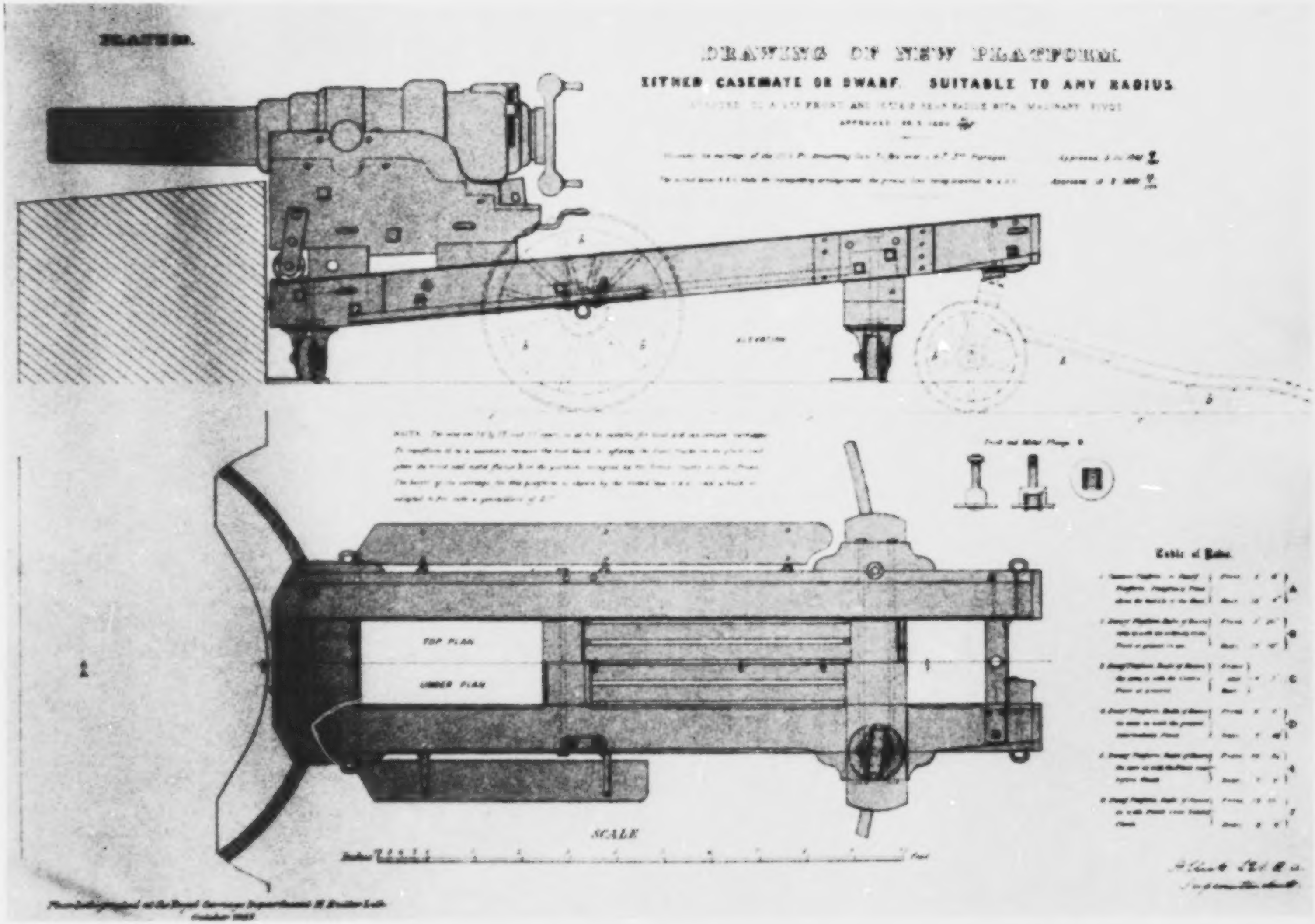


PLATE 60.
DRAWING OF NEW PLATFORM
EITHER CASEMATE OR DWARF. SUITABLE TO ANY RADIUS
ELEVATION
TOP PLAN
UNDER PLAN
SCALE
Table of Radii

Figure 193. Drawing of New Platform. Either Casemate or Dwarf. Suitable to any Radius. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 60, October 1868.)

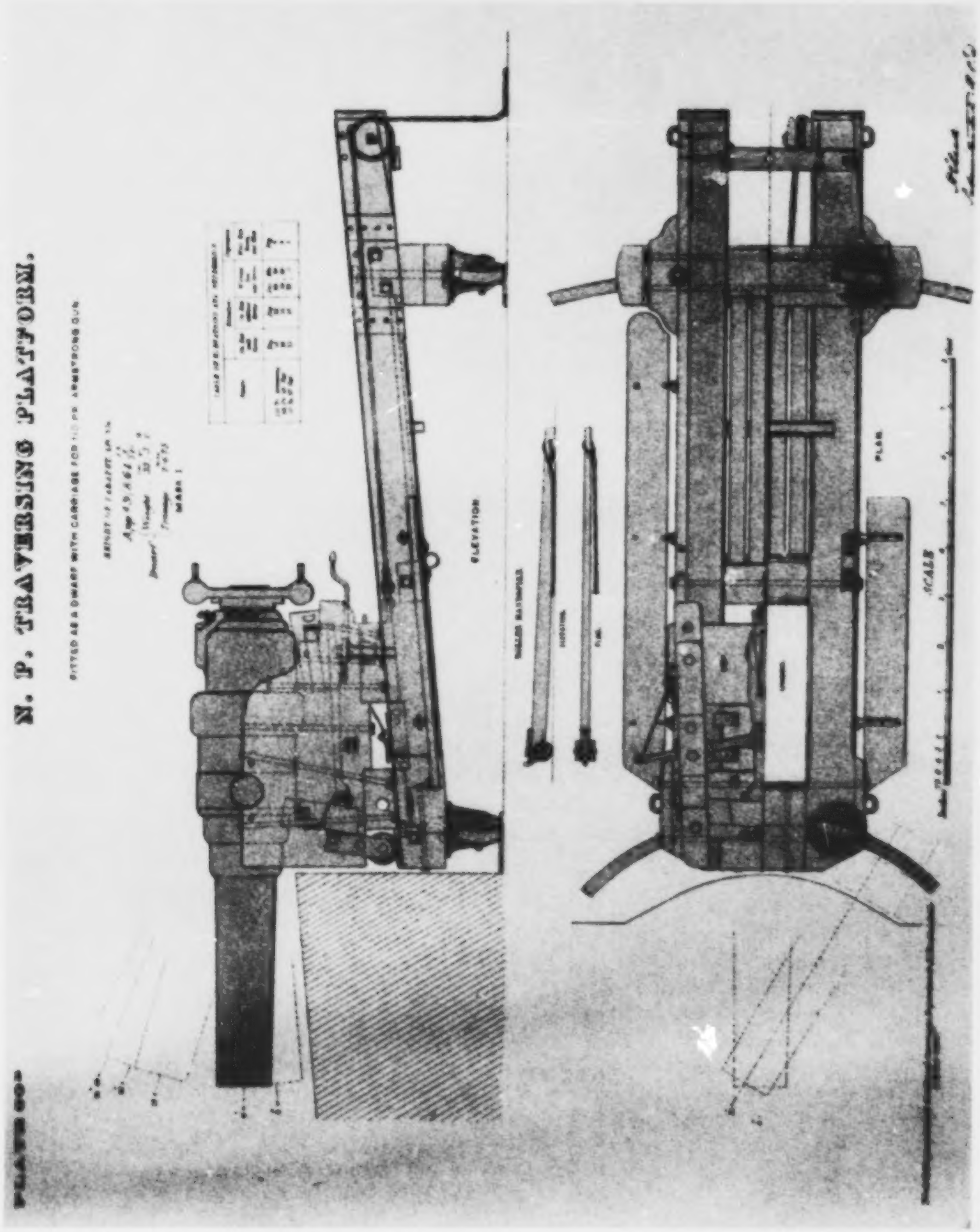


PLATE 60B
N. P. TRAVERSING PLATFORM.
FITTED AS A DWARF WITH CARRIAGE FOR 110 PR. ARMSTRONG GUN
ELEVATION
PLAN
SCALE

Figure 194. N.P. new pattern Traversing Platform. Fitted as a Dwarf with Carraige for 110 Pr. Armstrong Gun. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 60B, October 1868.)

set of racers. The dimensions of the other sets of racers remained the same. By 1860 then, the system of radii of racers measured from the imaginary pivot was as follows:

	Position	Radii	
		Front	Rear
A	at muzzle	5 ft.	16 ft. 6 in.
B	front	1 ft. 10 in.	12 ft. 10 in.
C	centre	6 ft. 1 in.	6 ft. 1 in.
D	intermediate	9 ft.	3 ft. 4 1/4 in.
E	rear before chock	10 ft. 8 1/4 in.	2 ft. 2 in.
F	rear behind chock	12 ft. 10 in.	2 ft. 2 in.

(E and F refer to a position just before or just behind the rear transom and block.)[33]

According to an amendment to a report by a committee on coast batteries, written in 1860, the above positions were appropriate in the following circumstances:

A. When firing through embrazures [sic], or en barbette, when the lateral range does not exceed 110°.

B. Ordinary front pivot...
For firing through embrazures [sic], or en barbette, when a pivot is used.

C. In salients, when en barbette, or whenever the lateral range exceeds 110°, and does not exceed 150°.
(This pivot is not adopted for firing round the entire circle, as its designation would imply.)

D. Intermediate pivot....In salients, whenever more than 150° lateral range is to be obtained, or whenever a fire is required throughout the entire circle.

E. Although the construction of a new parapet can always be suited to one of the foregoing cases, it may in many instances be found convenient to adopt this pivot, rear before chock whether in designing a new battery or in modifying an old one.

In the body of the report E was said to be "... for salients generally." (No specific mention was made of the F position, rear behind chock.)[34]

Casemate Traversing Platform

Because the genouillère of a casemate was lower than the normal parapet of 4 feet 3 inches, a modified form of the dwarf traversing platform was adopted for use therein. The front flanges and trucks were replaced by very small flanges and rollers (or trucks) and the rear block was removed so that the rear flanges and trucks could be mounted directly onto the side pieces. This was the only difference between the dwarf and casemate traversing platforms, although the latter seems not to have been available until 1860 for pieces heavier than the 8-inch gun.[35]

The development of the casemate traversing platform, then, followed generally that of the dwarf. There seems to have been some problems in keeping the small front rollers properly lubricated and, consequently, an improved flange was introduced in 1863.[36] The platform was always mounted on a front pivot, until the introduction of the system of imaginary pivots in 1860, when the imaginary pivot at the muzzle was adopted.[37] With the adoption of the New Pattern platforms in 1860, pieces heavier than the 8-inch gun could thereafter be mounted (Fig. 195).[38]

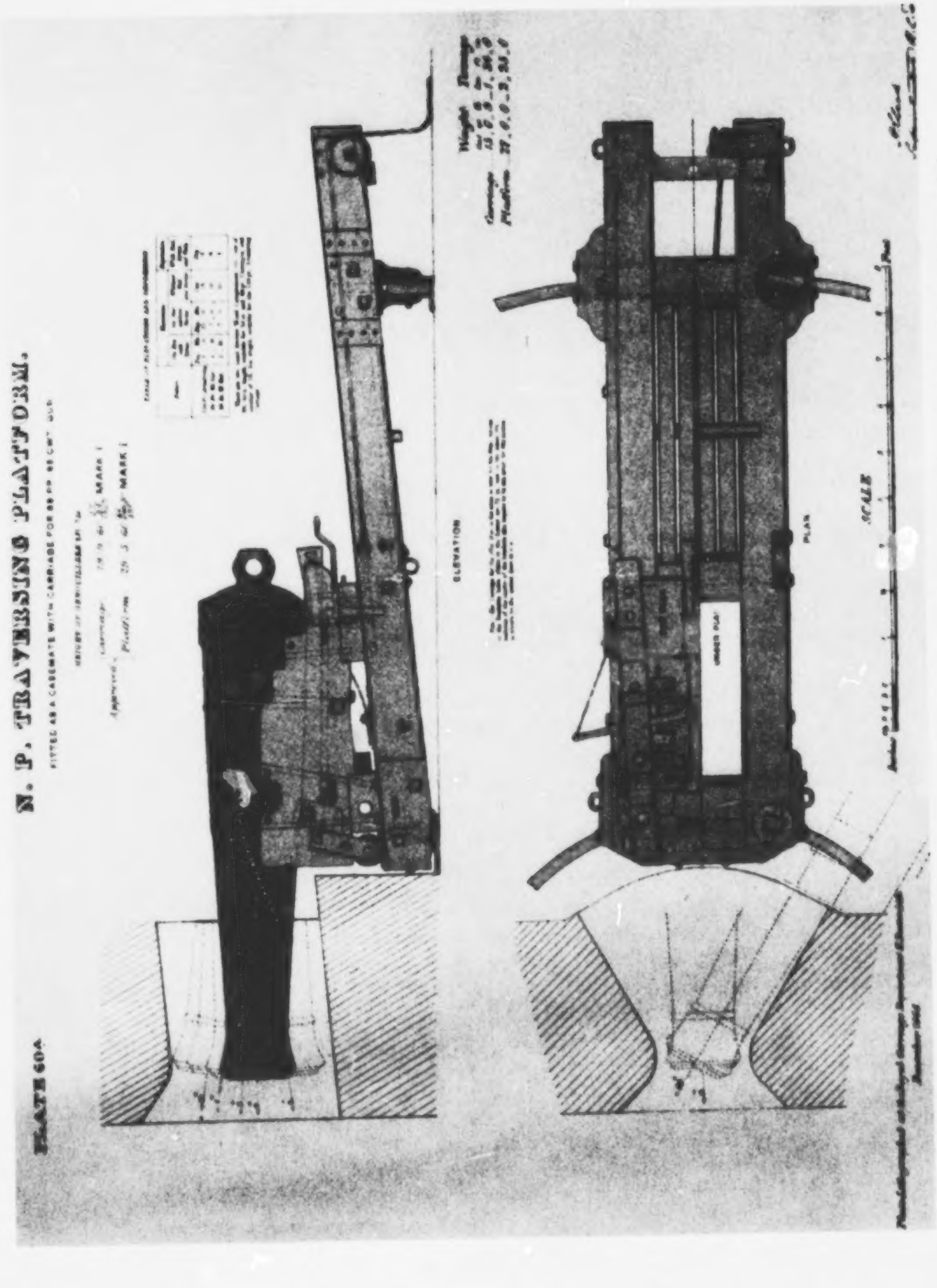


PLATE 60A
N. P. TRAVERSING PLATFORM.
ELEVATION
PLAN
SCALE

Figure 195. N.P. new pattern Traversing Platform. Fitted as a Casemate with Carriage for 68 Pr. of 95 cwt. Gun. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 60A, December 1868.)

Traversing Platforms (Iron)

Common Traversing Platform

The Ordnance also developed a platform of cast iron as an alternative to wood. The latter material, particularly in hot humid climates, rotted quickly; the former, properly cared for, lasted much longer. The precise date of the iron platform's introduction is not known, but a pattern was approved by the Board of Ordnance on 8 March 1824. The Aide-Mémoire noted that its use was regulated by an order of the Master General and Board of 9 March 1810, but initially this order seemed to apply only to iron gun carriages; it might be inferred, then, that the iron platform was developed subsequent to 1810 and finally standardized in 1824 (Fig. 196). There was only one design weighing 51 hundredweight, for 32-, 24-, and 18-pounder guns.[39]

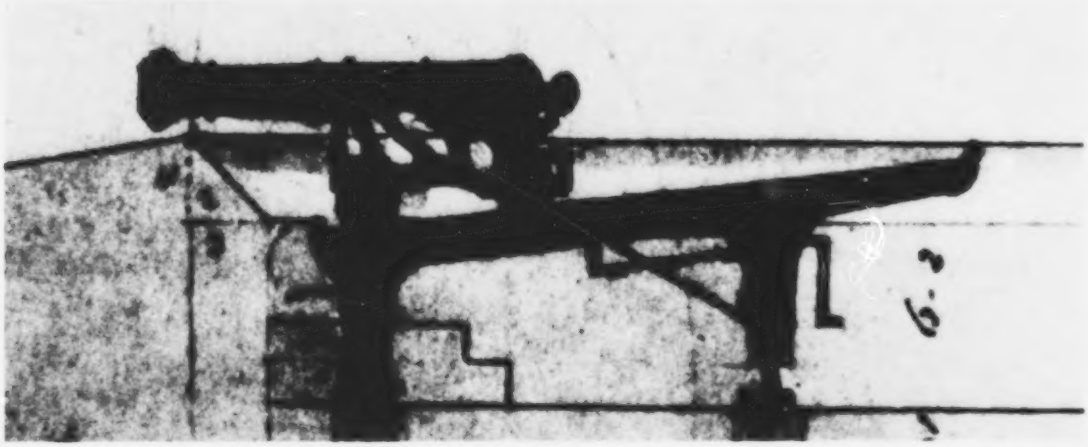


Figure 196. Iron Traversing Platform proposed for Fort George, Halifax, in 1825. (Cf. Figure 197.) (Great Britain, Public Record Office, W078/1786.)

According to the order of 1810, which came to apply to iron platforms as well as to iron carriages, they were "...to be placed in such parts of fortifications as are least exposed to the enemy's fire; and in sea batteries to which heavy ships cannot approach nearer than 1000 yards." Wooden carriages and platforms were to be kept in store to replace those of iron in case of attack. The splinters from an iron platform or carriage when shattered by shot would destroy nearby carriages and crews. As well, once damaged, they could not be repaired, while those of wood could usually be fixed on the spot.[40]

By the 1840s the use of cast iron carriages and platforms was being called into question and directions were issued to replace them with wood, although the immediate implementation of the order was to be left to the discretion of local authorities. In 1853 the Master General and Board approved a recommendation that no more iron carriages and platforms were to be constructed.[41] In 1860 a committee on coast defences made no recommendations on them "... as they believe that it is not intended that any more be made or issued."[42]

A scaled drawing of the pattern approved in 1824 was published in the Aide-Mémoire in 1846. It was similar to the wooden platform, but its legs were longer, its side pieces slightly shorter, and it had a somewhat steeper slope. Originally, it was mounted on a front, centre between the trucks, or rear pivot; later, a fourth position, middle of the length, was added as well. Although this is by no means clear, the diagram suggests that the trucks and truck housings were moveable to accommodate the different curves of the racers called for by the position of the pivot.[43]

There are 21 iron traversing platforms in the Grand Battery on rue des Remparts in Quebec City (Fig. 197).[44] Their designs are identical except that there are three minor variations in the front legs and two sizes in the depth of the side pieces. These trivial differences did not affect the function of the platforms. They are also similar in design to the diagram in the Aide-Mémoire with the major exception that the trucks cannot be adjusted and consequently they can only be mounted on a front pivot. It is not known when these platforms were cast.

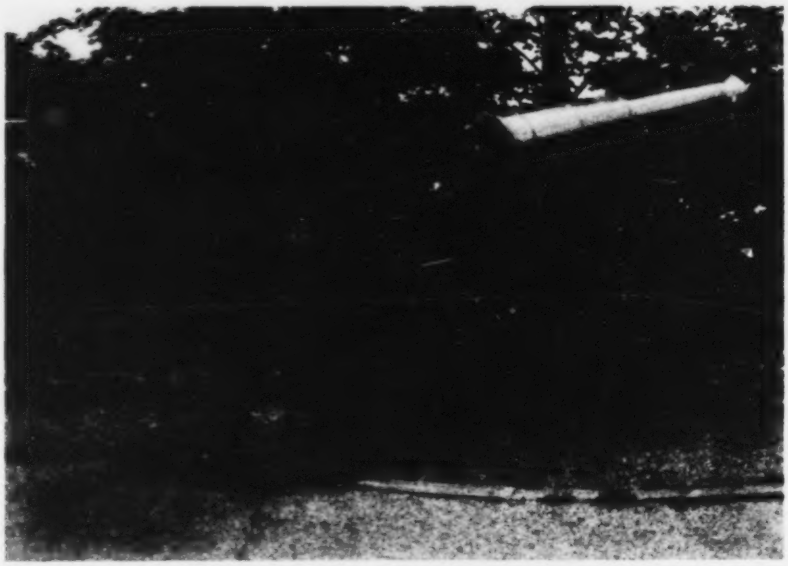


Figure 197. Iron Traversing Platform on a Front Pivot. (Parks, rue des Remparts, Québec.)

Dwarf Traversing Platform

There was also a cast iron dwarf traversing platform but almost nothing, except its weight, is known about it. In 1852 Griffiths recorded a weight of 52 hundredweight 5 pounds, and in 1859 of 50 hundredweight, implying perhaps, certain design changes. It was available for 8-inch, 32-pounder, and 24-pounder guns.[44]

GINS

Artillery or Triangle Gin

The Artillery or Triangle Gin[1] was a mechanical device used to mount or dismount artillery pieces onto or from their carriages or beds. Although details of its construction changed, its principle and design remained essentially the same for over a century, from at least circa 1750 to the 1860s. It was a tripod, two of the poles of which, usually called cheeks, were rigidly fixed together by two iron bars, one near the base and the other toward the mid-point of the triangle so formed.[2] The third or prypole was attached to these two at the apex of the triangle by an iron bolt which passed through the ends of the three poles. The bolt also secured an iron D-shaped shackle from which, by means of a hook, a tackle was suspended that was used to raise or lower the artillery piece.[3] The hauling part of the fall was wound round a roller or windlass set into the cheeks between the two iron support bars. The windlass was rounded towards its centre to take the rope and squared at each end. Handspikes or levers, fitted into holes cut into the square ends, were used to turn the windlass and thereby lift the piece. Later gins, beginning in the first decade of the nineteenth century, were equipped with a ratchet and pawl, connected to one end of the windlass, which prevented it from slipping back.

Early in the eighteenth century a heavier and more awkward gin, a circa 1714 drawing of which is extant, was in use (Fig. 198).[4] The basic tripod principle was evident, but the sides of the rigid triangle, about 8 feet long, were connected by four wooden cross pieces pinned into place. A wooden block about 2 feet long, which contained three sheaves, two above each other and the other to the side, was fixed to the apex of the triangle. A second block, double sheaved, was roved to it to form the tackle. The prypole, about 10 feet long, was attached to upper part of the standing block. The windlass was set into two uprights towards the base of the rigid triangle.

It is not known how long this gin remained in service, but by mid-century a lighter, simpler gin as described above was in use. Both John Muller in his A Treaties on Artillery (1757) and S. P. Adye in his artillery notebook (1766) drew and described this gin. Muller's description was the longer but both were clearly writing of the same machine. According to Miller, the gin

> consists of three round poles of about 12 or 13 feet long, whose diameters at the lower end are about four inches, five just below the roller, besides the cheeks that are added to them in that place, and about 3 or 3.5 inches above.
>
> The roller is 7 3/4 inches in diameter, and six feet long; 20 inches are left square at each end for the holes made in them to receive the hand-spikes, by which the roller is turned; the middle part is made round to wind the cable upon; the two poles, which support the roller, are fastened together by two iron bars, the one about 28 inches below the roller, and the other as much above it. These bars are fixed with one end to one of the poles by means of a bolt, and with the other end to the other pole with a bolt and key, so as to be taken out, in order that when the gin is to be carried abroad, the poles may lay close together upon the waggon; sometimes wooden bars are used instead of these iron ones, which cost less, and answer the purpose as well. There are two iron bands and two

> iron bolts to fasten each cheek to the poles, and likewise iron plates round the poles where the iron or wooden bars are fixed. The poles are hooped at each end, and those above have straps, through which the iron bolt passes. This bolt keeps the upper ends together, as likewise serves to support the iron to which the windless [sic] is hooked: this windless contains two brass pullies, about which the cable goes, which is fixed to the dolphins of the gun or mortar with another windless, containing two brass pullies likewise.

The accompanying diagram showed a spike in the bottom end of each pole to prevent it from slipping when the gin was erected.[5]

Again it is not clear how long this particular model was in use, but some time before 1800 a slightly taller gin, undoubtedly of the same basic design, came into service. According to Adye's manual of 1801, arms of this gin were 16 feet 4-1/2 inches long and the roller 6 feet long. The tackle fall was 3-inch white rope, 78 feet long, and the sling was 6-inch white rope. The 1813 edition of the manual recorded a change in the rope dimensions: the fall was now 5-inch white rope, 14 fathoms 2 inches (84 feet 2 in.) long and the sling was 6-3/4-inch white rope, 4 fathoms (12 feet) long.[6] It is difficult to say if these changes were merely corrections of errors or if they did reflect actual changes.

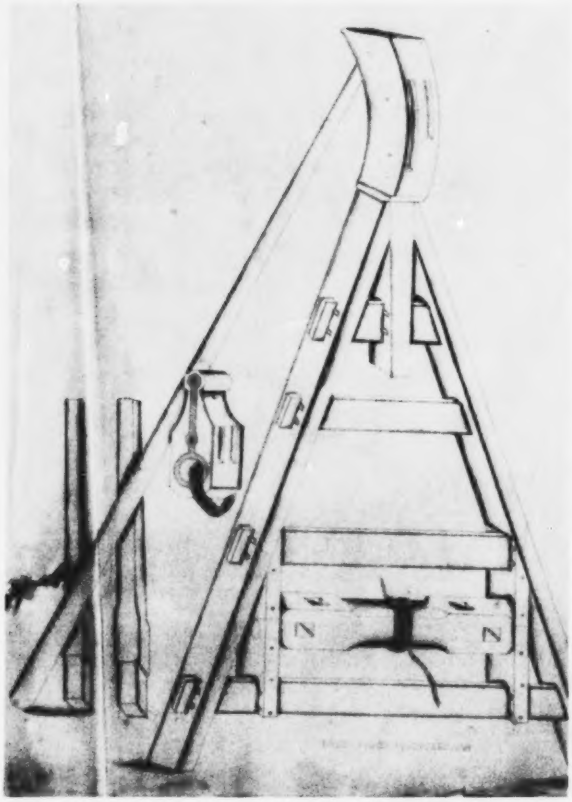


Figure 198. Artillery Gin, circa 1714. (The Royal Artillery Institution, Woolwich, U.K., Borgard, "Practiss of Artillery.")

This gin was adequate to lift guns onto or from garrison and siege carriages, but with the introduction of the long-legged traversing platform in the first decade of the nineteenth century a taller gin was introduced. As early as April 1807 "One Triangle Gin, new Pattern for Traversing Platform" was being sent to Quebec.[7] This undoubtedly was the machine described by Adye in 1813:

> Gin – Large Triangle, new Pattern – Length of arms, 18 feet 6 inches; roller 7 feet 4 inches; racket [sic] wheel, diameter, 1 foot 2 inches; length of the pall [sic], 1 foot; weight, 8 cwt. 2 qrs. 16 lbs. This gin is intended for mounting guns on traversing platforms.[8]

This is the first mention of a ratchet and pawl, an innovation attached to the end of the windlass of the large gin.[9] Since rope was not mentioned, presumably the rope for slings and tackle was the same as that used for the small gin.

Evidently the new gin was found to be inadequate for it was further modified, probably in the 1820s. In 1828 Spearman's manual indicated that the length of the cheeks and prypole had been increased to 20-1/2 feet and that the windlass, which was 9 inches square at its ends, had been shortened slightly to 6 feet 9 inches. The ratchet wheel was 12 inches in diameter and 0.25 inch thick. To reeve the tackle 3-1/2-inch rope, 16 fathoms (96 feet) long, was to be used. For the small gin the rope was only 72 feet long. The tackle was composed of a double and treble block roved together.

According to Spearman, the small gin had changed little. The cheeks and prypole were 16 feet 3 inches long and the windlass, which was 8 inches square at its ends, was 5 feet 11 inches long. Like the large gin it had a ratchet wheel of the same size. These dimensions are at slight variance with those given in 1813. The difference in the length of the arms of 1-1/2 inches seems insignificant; the shortening of the windlass by 1 inch may be accounted for by the introduction of the ratchet wheel.[10]

There are a number of drawings in notebooks of students at the Royal Military Academy during the 1820s that showed the gin fully erected and supporting a gun. The method by which the gun was raised is quite clear. A sling of rope, doubled and joined at the ends, was twisted and then looped over the cascable at one end and a fid inserted into the bore of the gun at the other. The sling was caught a little behind the trunnions by the lower hook of the tackle whereby the gun was raised. One drawing showed the gunners in the process of lifting a large gun (Fig. 199).

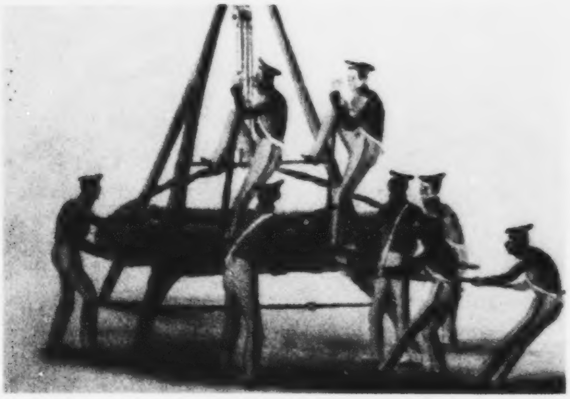


Figure 199. Artillery Gin in use, circa 1830. (The Royal Artillery Institution, Woolwich, U.K., Robert Cockburn, "Practical Course of Instruction.")

Interestingly, two of the gunners responsible for heaving on the levers to turn the windlass were standing on the windlass, each with one foot braced against the upper iron support bar, presumably to gain added force as they pull down on the levers. Other gunners are pulling on the fall to take up slack. When the gun was raised to the required height two levers were left inserted in the windlass resting against the upper support bar and the fall was tied off around the lower bar. This can be clearly seen in a drawing of 1825 (Fig. 200).

The various pieces of hardware can be clearly seen. The ratchet and pawl were evident. Each iron support bar had an extra eye in it at such a distance so that when the gin was taken down and one end of the bar unkeyed it could swing and be keyed in place on the cheek. Two strengthening bands have been wound around the squared ends of the windlass. One drawing appeared to show a ring inserted low down into the prypole which would take a handspike as the gin was raised. The D shackle and connecting bolt were clear and the tackle appeared to be composed of a treble and double block, the former hooked to the shackle. The drawing of 1825 showed a method to prevent the gin sinking into wet ground. The ends of the poles were inserted into wooden trucks.[11]

The only scaled drawing from this period that has been found was of the small gin contained in the Aide-Mémoire (Fig. 201). The cheeks were 16 feet 3-3/4 inches and the prypole 5 feet 10-1/2 inches long; the ends of the latter were 7-1/2 inches square. The various pieces of hardware, including the ratchet (said to be 11 inches in diameter) and pawl, were clearly drawn. The differences in dimensions between this gin and the one outlined by Spearman appear insignificant. A detailed drawing of the large gin was not given, but it was said to be 20 feet long, a length similar to that given by Spearman.[12]

Some additional information was given in Griffiths' manuals in the 1840s about stores needed to work the gin. The slings, which Spearman did not mention, were of

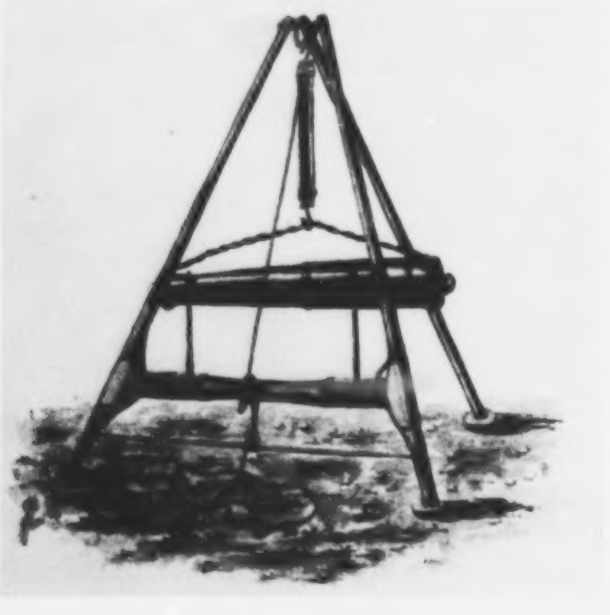
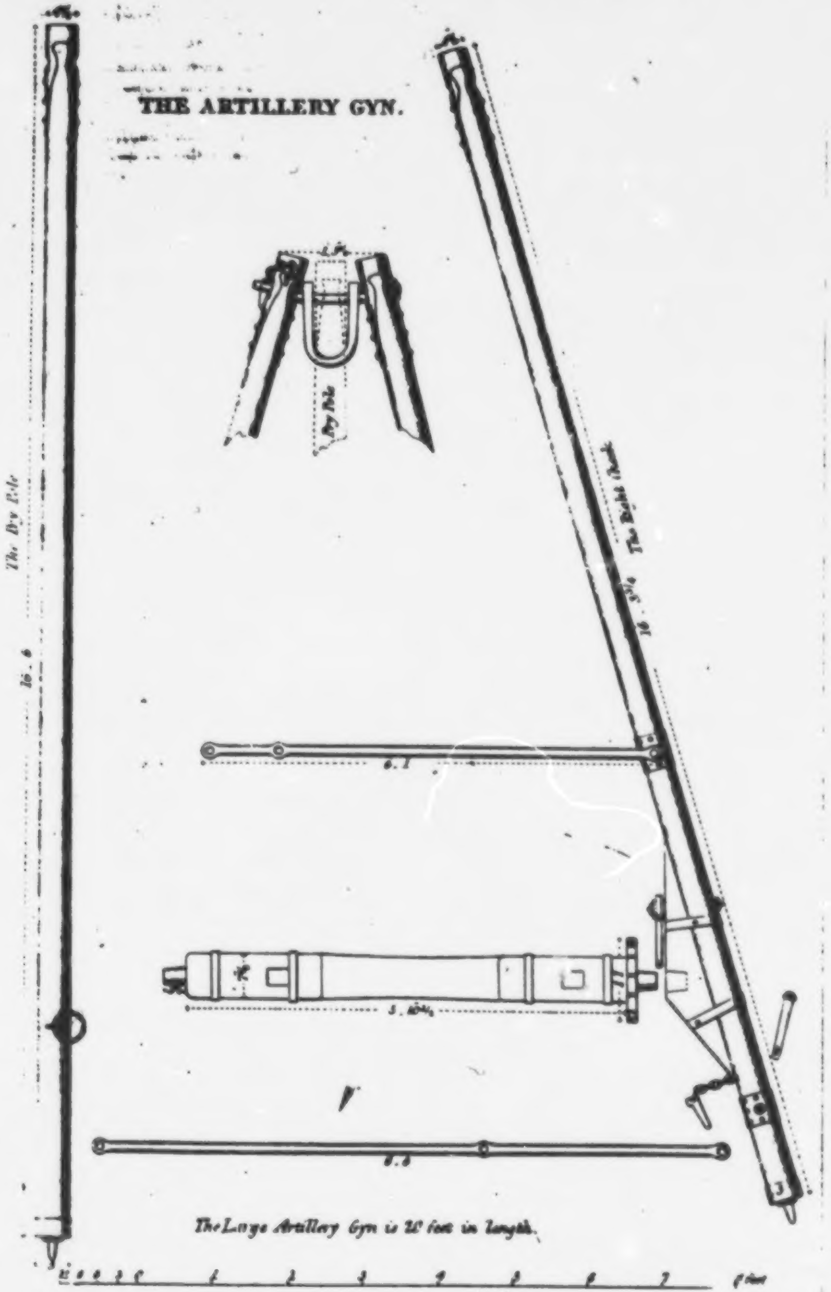


Figure 200. Artillery Gin, circa 1825. (Royal Military College, Mould, p. 221.)

5-inch-white rope, of three different sizes according to the nature of the piece. A smaller rope, 2-1/4 inch, 2 fathoms (12 feet) long was used to sling mortars and a piece of skidding or large block of wood, rather than a fid, was inserted in the bore.


THE ARTILLERY GYN.
The Pry Pole
16 . 6
Pry Pole
The Right Cheek
16 . 3¼
6 . 1
5 . 10¼
8 . 6
The Large Artillery Gyn is 20 feet in length.
12 6 0 3 0 1 2 3 4 5 6 7 8 feet
J.K. Lowry sc.

John Weale, 59 High Holborn, 1846

Figure 201. The Artillery Gin. (Aide-Mémoire (1853), Vol. I, Derrick (Sheers & Gyn) Plate 3.)

A piece of spun yarn, 3 stranded, 1-1/2 fathoms (9 feet) long was required to seize the clinch of the fall where it was attached to the tackle. Three small trucks, or pieces of board, 4 inches thick, with a small hole to take the spikes on the ends of the pole were used on soft ground. In addition, the large gin required a 4-inch block and 60 feet of 1-1/2 inch rope. No explanation was given but later authorities indicated that the block was hooked to a ring on the end of the prypole and used to pull the tackle up to be attached to the D shackle. Two double lashings were also indicated for breech and muzzle ropes or guys, presumably to control the gun as it was raised or lowered.[13]

About 1860 the gin of 20 feet was superseded by one of 18 feet. The smaller gin of 16 feet remained in service. Details about the new 18 foot gin are scant other than that its cheeks were 18 feet and its windlass 6 feet 9 inches long. Certain changes in the stores were indicated, however. The levers, which were 6 feet 9 inches long, were fitted at their small end with 2-1/2 fathom (15 feet) of 2-inch tarred rope by which the levers could be pulled down to turn the windlass. This would render unnecessay the rather clumsy method of standing on the windlass shown in the drawing of 1830. The slings were now of 6 inch rope in 2 lengths, 11 feet and 10 feet as measured from bight to bight. Mortars were slung by 2-1/2-inch rope. The tackle was composed of two 12-inch blocks, usually 1 double and 1 treble, but for very heavy weights, like 68-pounder and 10-inch guns, 2 treble blocks were used. The trucks to be used on soft ground were 12 inches in diameter and 3-1/2 inches thick. Four common handspikes, 6 feet long, were also necessary to each gin.[14]

Writing in 1864, Miller outlined the use of the two gins:

> ... the larger is furnished to siege trains in the proportion of 1 to 9 pieces of heavy ordnance, the smaller is furnished to every battery of position. The 18-feet gun will raise guns of any weight, the 16-feet gyn is not suitable for weights above 56 cwts.; but two may be used, if the 18-feet gyn is not available, for mounting the 10-inch, 8-inch (of 60 cwt. and 65 cwt.), 68-pounder, 56-pounder, 42-pounder guns, and the heavier nature of 32-pounder guns.[15]

By 1867 the design of the gins had undergone more changes. There were then three gins, two of 18 feet and one of 16 feet. The larger gins were used for garrison and general service. The heaviest of the two, weighing 24 hundredweight, was designated "18 feet strengthened gyn" and was capable of lifting 12 tons (Fig. 202). The lighter one, weighing 13-1/2 hundredweight, was named "18 feet gyn with strengthened windlass," and was used for mounting guns weighing up to 95 hundredweight. The windlass was strengthened by the substitution of wrought for cast-iron. The 16-foot gin, which was used with heavy batteries, weighed 9 hundredweight and was capable of raising 56 hundredweight.[16] The main improvement in design was the development of a more sophisticated ratchet device on the windlass which allowed the lever to be pushed backwards without rotating the windlass. The various details of the strengthened gin, whose pattern was approved on 6 March 1866, were evident in a drawing produced by the Royal Carriage Department.[17]

Gibraltar Gin

Since the triangle gin could not be used in casemated batteries or other confined spaces in garrison, a more compact gin, the Gibraltar Gin was developed. It is not known when it was invented, but its name suggests that its provenance was the

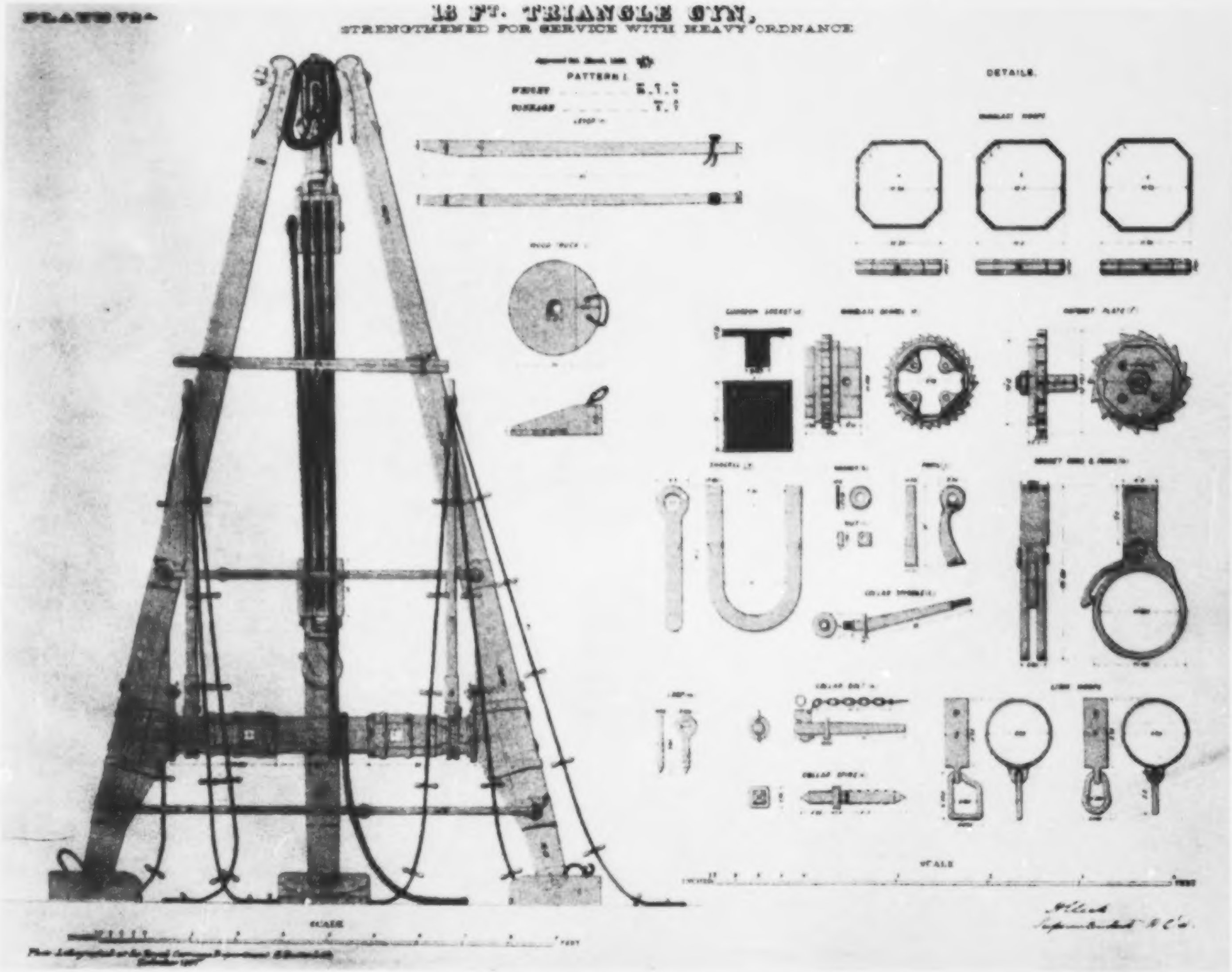


PLATE 72A
18 FT. TRIANGLE GYN,
STRENGTHENED FOR SERVICE WITH HEAVY ORDNANCE
PATTERN I
DETAILS.
SCALE
SCALE

Figure 202. 18 Ft. Triangle Gyn. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 72A, November 1867.)

great fortress at Gibraltar. The earlist reference to it yet discovered is a drawing in a notebook of John Cockburn, a student at the Royal Military Academy, circa 1820.[18] Thereafter there is evidence of the use of the gin well into the 1860s.

The Gibraltar gin consisted of a horizontal cross bar supported by two uprights which were fixed to two axletrees mounted on four iron tracks (Figs. 203 and 204). Attached to one upright was a windlass turned by a crank and small pinion wheel geared to a larger spur wheel. A ratchet and pawl attached to the windlass locked it in position. A rope passed around the windlass, up over a sheave set into the horizontal bar near its end, and then down around a treble sheave set into the middle of the bar. To complete the tackle the rope was rove through a metal treble block to which was fixed a horizontal iron bar. Rather than being slung, the artillery piece was lashed to this bar the ends of which were turned up to prevent the lashings from slipping off.

The gin did not change much in design between circa 1820 and 1866 when the plans produced by the Royal Carriage Department were approved. The main improvement was to increase the lifting power of the windlass. In the early 1820s the difference in size between the pinion and spur wheels was small; by 1830 this arrangement had been modified and the spur wheel had become much larger, thereby augmenting the lifting power of the windlass.[19] In the 1860s it could lift 3 tons safely.[20]

There are a number of drawings of the Gibraltar gin but little detailed written material about it. In his manuals in the 1840s and 1862 Griffiths provided some information as did Miller in his Equipment of Artillery in 1864. In 1862 Griffith gave its weight at 10-3/4 hundredweight while in 1864 Miller put it at 14-3/4 hundredweight. Unless Griffiths was in error this difference probably indicated some changes in design; moreover, Miller's weight was the same as that of the gin the design of which was approved in November 1866.

If the information given by Griffiths and Miller are combined, a more complete picture of the gin emerges. It was of wood, 8 feet long and 8 feet high. It could be moved over short distances by dragropes hooked onto staples set into the front or

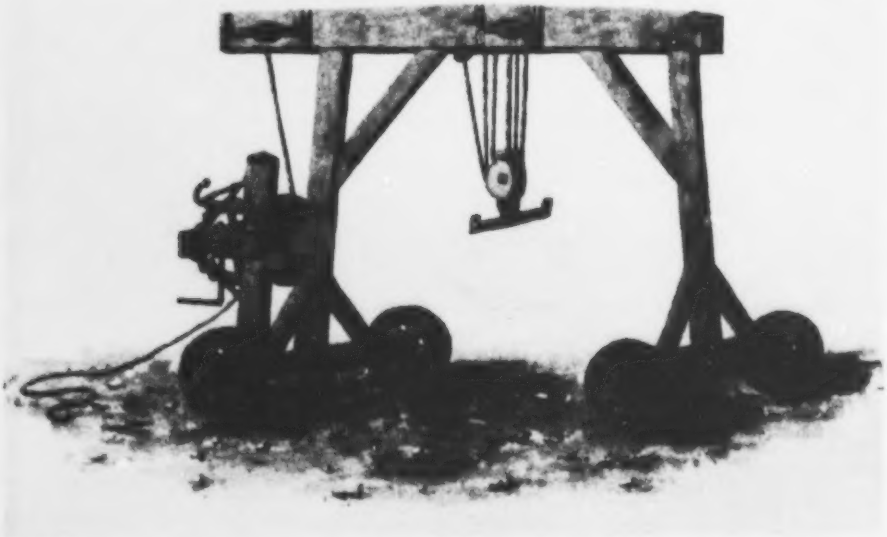


Figure 203. Gibraltar Gin, circa 1825. (Royal Military College, Mould, p. 224.)

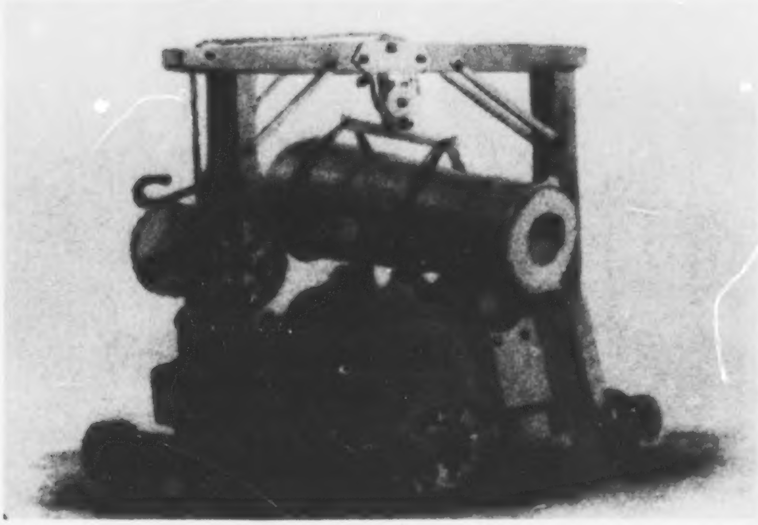


Figure 204. Gibraltar Gin in use, circa 1830. (The Royal Artillery Institution, Woolwich, U.K., Robert Cockburn, "Practical Course of Instruction.")

rear axletrees. In order to work it the following stores were needed:

One fall of 3 1/2 inch white rope, 8 fathoms (96 feet) long;
Two lashings for slinging the gun of 2 1/2 inch tarred rope, each 20 feet long;
One stopper about 5 1/2 feet long of 2 1/2 inch tarred rope, more than one-half plaited as a gasket (the purpose of this remains a mystery);
One 12 inch iron treble block with brass sheaves to which was attached an iron bar 2 1/2 feet long for suspending the gun, its ends turned up;
Four handspikes, common, 6 feet long;
Two heavy dragropes.[21]

The details of the Gilbraltar gin as approved on 2 November 1866 can be seen in the elevation and plan produced by the Royal Carriage Department (Fig. 205).[22]

Bell's Gin

Similar to the Gilbraltar gin but much lighter in construction and weaker in power (it could lift no more than about 30 hundredweight), Bell's Gin was developed to mount or dismount heavy field artillery or carronades. Instead of a windlass with pinion and spur wheels, a rack and pinion device, working down through the centre of the horizontal beam, was used to lift the artillery pieces. The vertical rack ended in a hook from which the piece, lashed to an iron bar, was suspended. The pinion wheel that moved the rack was worked by a set of four handles on each side. Around each set a rope was wound so that, by pulling on it, the handles were turned and the rack was raised.

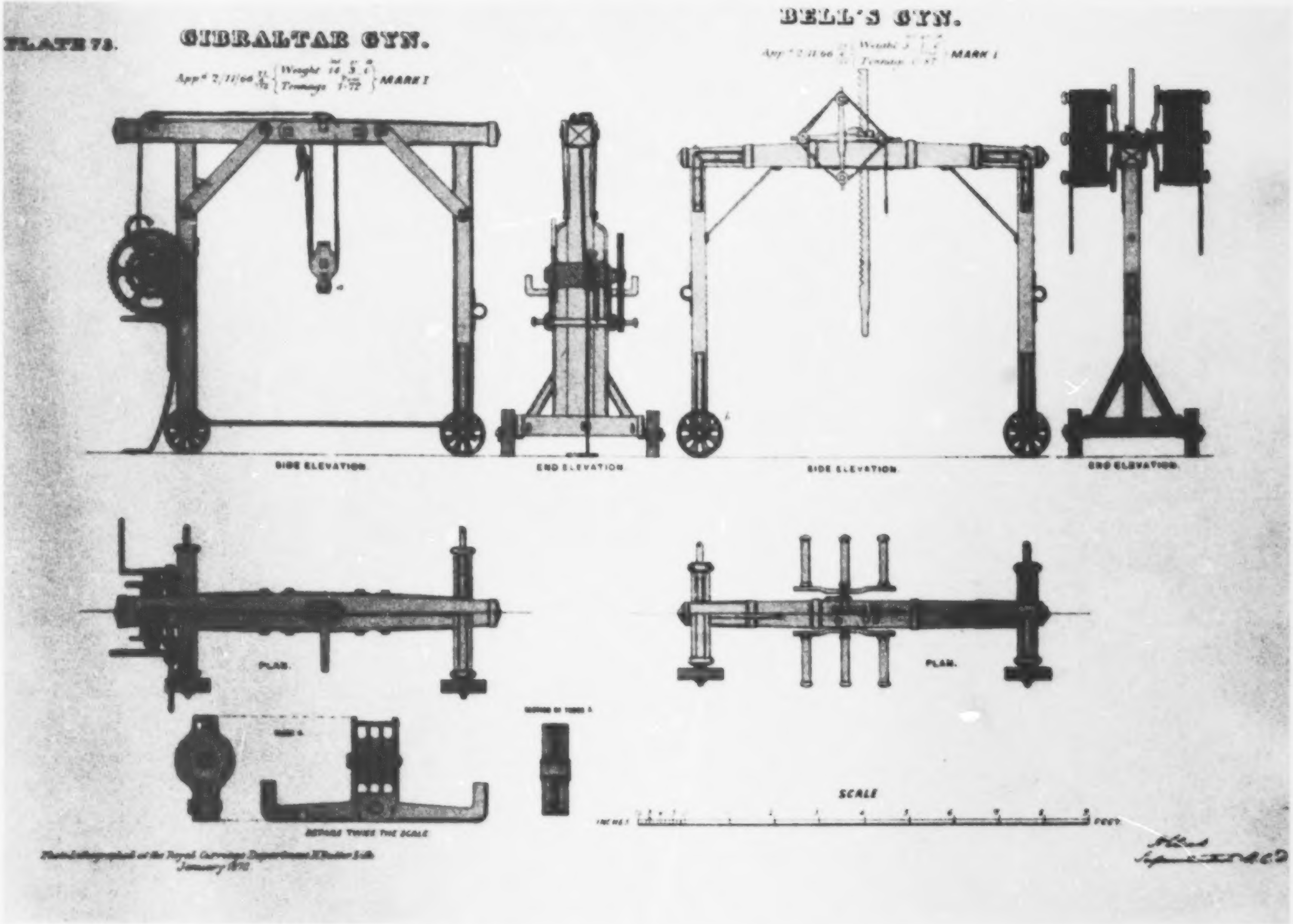


PLATE 73.
GIBRALTAR GYN.
MARK I
BELL'S GYN.
MARK I
SIDE ELEVATION
END ELEVATION
SIDE ELEVATION
END ELEVATION
PLAN.
PLAN.
SCALE
INCHES
FEET

Figure 205. Gilbraltar Gyn. Bell's Gyn. (The Royal Artillery Institution, Woolwich, U.K., Royal Carriage Department, Plate 73, January 1870.)

The earliest reference found to Bell's gin was in 1825 in a notebook of a student at the Royal Military Academy (Fig. 206).[23] It was still in use in the 1860s but references to it were scant from the 1820s to the 1860s. Only Griffiths gave any information about its stores:

> Two pieces of 2 1/2 inch tarred rope, each 20 feet long, for lashings;
> One suspending bar;
> Two pieces of 1 1/2 inch rope, each 12 fathoms (72 feet) long, for winding round the sets of handles.[24]

The details of this gin can be seen in the plan and elevation, approved 2 November 1866, produced by the Royal Carriage Department (Fig. 205).[25] With the obsolescence of heavy field guns and the use of light pieces which could be manhandled, Bell's gin probably had little use by the 1860s.

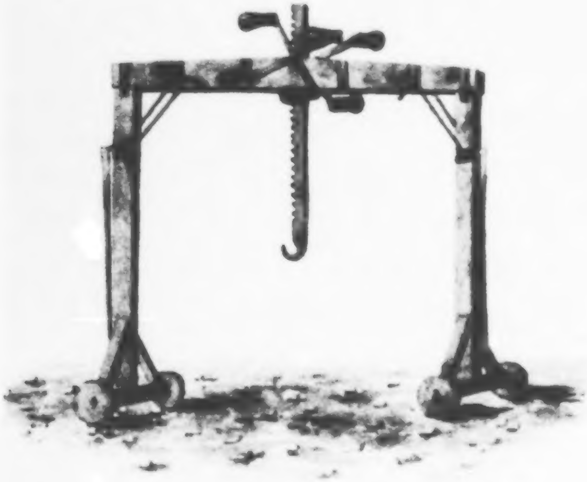


Figure 206. Bell's Gin, circa 1825. (Royal Military College, Mould, p. 222.)

GUNPOWDER AND CARTRIDGES

Introduction

Gunpowder is a mixture of saltpetre (potassium nitrate), sulphur, and charcoal. Saltpetre was the most important of the three ingredients, but the other two were necessary, if ancillary, to the production of good gunpowder. Their proportions, which were worked out by trial and error, varied from country to country and from time to time. From about 1260, when Roger Bacon cryptically wrote out the formula, to about 1780 when the final proportions were established, the amount of saltpetre was gradually increased with a corresponding decrease in the quantities of sulphur and charcoal.

Year	Saltpetre	Sulphur	Charcoal
1260	41.2	29.4	29.4
1350	66.7	11.1	22.2
1647	66.6	16.6	16.6
1670	71.4	14.3	14.3
1742	75.5	12.5	12.5
1781	75.0	10.0	15.0[1]

Although the quality of gunpowder improved after 1781, its compositon remained unchanged until the end of the smooth-bore era.[2]

Equally important, perhaps even more so, to the production of good gunpowder was the method of manufacture. The earliest form, called serpentine, was a dry mixture of the three finely ground ingredients. Unfortunately, because of its compactness, it burned slowly and therefore imparted a relatively weak velocity to the projectile. Also, it stored poorly, and if transported for any distance, it tended to separate into its component parts. To solve this problem, early powder-makers developed the technique of corning: after they had mixed together the three ingredients, they dampened the gunpowder and rubbed it through a sieve, thereby creating corns or grains, each of which was an integrated miniature combination of its three elements. It stored much better in this form, since it was less likely to absorb moisture; it travelled better, since it did not separate into its components; and it burned more quickly, thereby discharging the projectile with greater force. Although corned powder was known from about 1450, it was not used for artillery in England until about a century later.[3]

Corning was a major innovation in the manufacture of gunpowder, but despite the improvement, by the time of the American Revolutionary War, "...the inferiority of the English gunpowder to that of the enemy, [sic] was the constant subject of complaint both in the navy and army..."[4] The problems were various, but one, the impurity of charcoal, was pinpointed by Richard Watson, ecclesiastic and chemist, who suggested an improved method for its production. Instead of the traditional burning of wood in large piles covered with earth and sod in the forest, he recommended that it be charred in closed iron containers, the acid and gas by-products being carried off, leaving a much purer charcoal. (For a more detailed description, see below.) The adoption of Watson's suggestion resulted in a more powerful gunpowder and in a consequent reduction of the service charge.

The Manufacture of Gunpowder

Saltpetre

The saltpetre used in the production of gunpowder was either imported from the East Indies or extracted from damaged gunpowder. Brought into England in a grough or rough, semi-refined state by the East India Company, it was purified by a process of "solution, filtration, evaporation, and crystallization."[5] A mixture of the grough salt and water was boiled in a large copper for about 3-1/2 or four hours, until the scum, which was periodically skimmed off, ceased to form on the surface of the liquid. Occasionally, cold water was thrown in to aid in the formation of the scum and to precipitate other impurities to the bottom. When the process was completed, the fire was put out and the liquid was allowed to cool to some extent to precipitate more impurities.

After cooling for about two hours, the liquid, or liquor as it was called, was ladled or pumped through a spout into a trough with four brass cocks. These controlled the flow of the liquor into inverted cone-shaped, double-canvas filtering bags, each containing a little sand to prevent the too quick passing of the liquor. Collected in pails, the liquor was filtered repeatedly until it ran completely clear. Then the filtrate was transferred to special crystallizing pans. There, as it continued to cool, crystals of saltpetre precipitated. When the crystallization was complete, the liquor (called the mother liquor) was poured off and reserved, and the saltpetre allowed to drain for 24 hours. The salt was then boiled, filtered, and crystallized twice more in the same way, except less water was used each time. The mother liquor, reserved after each refining, was boiled, filtered, and allowed to crystallize; since the resulting salt was considered equivalent to grough saltpetre, it was mixed with the next quantity of impure saltpetre for refining. Thus as little as possible was lost during purifying.

To evaporate water trapped inside the crystals, the triple refined saltpetre, usually in units of about 4 hundredweight, was fuzed in iron pots, care being taken that it not boil lest it be spoiled by the formation of a nitrite. The melted saltpetre was poured into circular gun metal moulds to form cakes. Once cooled they were packed in barrels and stored until needed.[6]

Although there were minor variations, the basic method of refining saltpetre remained unchanged until about 1850, when a more efficient procedure was adopted at the Royal Gunpowder Factory at Waltham Abbey. A mixture of the salt and water (40 hundredweight to 270 gallons) was boiled and filtered in the usual manner. The filtrate was run into large copper lined troughs, where it was agitated by wooden rakes until it was nearly cold, whereby a large quantity of small crystals of saltpetre were precipitated. The salt was collected with a wooden hoe as it formed, shovelled onto copper sieving above the trough to drain, and raked into a washing vat where it was rinsed with cold water for an hour. After it was drained, the saltpetre, which was equal to that triple refined by the older method, was dried on large copper trays fitted over furnace flues and subsequently barrelled for use. The mother liquor left over from the agitation was first allowed to sit overnight to precipitate large crystals; then it was boiled, filtered, and allowed to crystallize. Both these precipitates were added to grough saltpetre for refining.[7]

Saltpetre could be recovered from badly damaged gunpowder by a process similar to refining. A mixture of the damaged powder and water was boiled for 1/2 hour in a large copper and then filtered through double-canvas bags until it ran clear. The black residue left in the filter bags was emptied back into the boiler, mixed with clean water, boiled, and filtered as before. The residue left was carted off to be buried. The filtrate was poured into another boiler and reduced until at the point of crystallization, when it was filtered into pans and allowed to stand while the precipitate formed. The saltpetre was drained, rinsed in cold water, and drained again for 24 hours. After being dried, it was treated as grough saltpetre and purified in the usual manner.[8]

About 1785, William Congreve, the elder, improved the method of extracting saltpetre from damaged gunpowder by designing a machine to press all the liquor out of the black residue. The boiled mixture of water and gunpowder was first passed through a large filter bag, in which the black residue was retained, and then through the small filter bags to be collected and processed as usual. The black residue in the large bag was pressed as dry as possible on Congreve's machine, the liquor passing through the small filter bags for the usual treatment. The bag was emptied and the residue processed once more before being discarded.[9] According to Congreve, his method resulted in an extra 6 pounds of saltpetre being recovered from every 100-pound barrel of damaged powder.[10]

Sulphur

Most of the sulphur used by the Ordnance was imported from Sicily in a crude, unrefined state, although some attempt was made to use that dug from the copper mines in the Isle of Anglesea, but it could not be successfully separated from its arsenic content.[11] Until about 1850, the Sicilian sulphur was purified by a simple process of melting the ore in pots, skimming off whatever impurities rose to the surface, and then allowing the molten sulphur to cool and harden in tubs. During the cooling, impurities rose to the surface or sank to the bottom, leaving the purest sulphur in the middle. The impure sections were sawn off and the purer sulphur was remelted, skimmed, and hardened once or twice more, until sufficiently pure sulphur was obtained. Finally melted and cast in wooden moulds into "roll sulphur," it was ready to be used in gunpowder manufacture.[12] One manual noted: "A trifling degree of impurity in this ingredient is, however, of no moment; roll sulphur alone is therefore used in the government mills..."[13]

By the 1860s, the Ordnance had found this process to be unsatisfactory, and a different method of refining sulphur was devised at the Royal Gunpowder Factory at Waltham Abbey. A large iron retort, with a tight fitting lid, was built into brickwork over a furnace. Two pipes, each fitted with a sluice cock, branched off in opposite directions from the top of the retort, one leading to a small room, the subliming chamber, and the other to a tank, the distilling chamber. The latter pipe and chamber were encased in a jacket through which cold water was circulated.

About 6 hundredweight of crude sulphur (i.e. once refined by a simple process of distillation) was loaded into the retort, and a slow fire was lit in the furnace. The cock in the pipe leading to the subliming chamber was opened and the other was closed. As the sulphur melted, it began to evaporate into a yellow vapour, passing through the opened pipe into the subliming chamber, where it fell to the floor as "flowers of sulphur." After about 1-1/2 or 2 hours, as the heat increased, the vapour in the retort became a deep red brown, whereupon the open cock was closed and the cock in the pipe leading to the distilling chamber was opened. Passing into this pipe, which was cooled by the water circulating around it, the vapour condensed into a thick yellow liquid that flowed into the distilling chamber. After it had cooled somewhat, it was run off into tubs to be thoroughly cooled. Because the flowers of sulphur contained sulphurous acid, they were suitable only for laboratory work; the crystalline sulphur was used in the manufacture of gunpowder.[14]

Charcoal

The traditional method of manufacturing charcoal had been practiced in the woodlands of England for centuries. The wood was usually cut in winter, corded, and left to season until summer, when it was charred. A circular area was stripped of sod, which was set aside, and the bare earth pounded into a hearth. The wood to be charred was systematically piled up from the centre into a conical or semi-spherical mound, with a central hole left for a chimney. The mound's exterior was covered with sod, the grass side inwards, and the seams were pointed to exclude air as much as possible. The wood was ignited by dropping burning pieces of charcoal or chips of wood down the chimney, which was then closed up. Circles of holes were pierced into the mound to provide sufficient draught to keep the fire going and to conduct it throughout the pile. When all the wood was completely charred and the fire extinguished, the mound was opened and the charcoal taken out. Although any wood could be used, it was found that alder, willow, and especially dogwood made the best charcoal for gunpowder manufacture.[15]

Seeking to find ways to increase the strength of gunpowder, in 1786 the government approached Richard Watson, the Bishop of Llandoff, who, as well as being an ecclesiastic, was a chemist of considerable reputation. He suggested that purer charcoal could be produced by distilling the wood in closed vessels. Watson's method was tried at Hythe in 1787, and the gunpowder made with the cylinder charcoal, as it was called, when tested, was found to be more powerful than the old gunpowder by a ratio of 5 to 3. Cylinder charcoal was not introduced generally until about 1794, but it proved so successful that it completely supplanted pit charcoal in the manufacture of gunpowder. To produce sufficient quantities of the purer charcoal, the Ordnance established its own manufactories, first, in 1800, in the Sussex Weald and then, following the Napoleonic Wars, at Faversham. Finally, in 1831, production was transferred to the Royal Gunpowder Factory at Waltham Abbey.[16]

Because Watson's method of production ensured a more complete charring of the wood than the traditional way, it produced a purer charcoal. Iron cylinders, usually in sets of three, each 6 feet long and 2 feet in diameter, were placed horizontally in brickwork over a grate. One end of each cylinder was closed, except that two copper pipes projected from it leading to two barrels. The wood to be charred — seasoned, the bark removed, and cut into short lengths — was piled into each cylinder. The open end was closed with a metal stopper, which was filled and rammed with sand, and a "sand door," similarly filled with sand, was fitted over the opening. (The precise method of closure is slightly obscure, but the purpose is clear enough — to make the cylinder as air tight as possible.) A fire of sea-coal was lit in the grate, and as the wood in the cylinder charred, gas and tar passed out through the pipes, the tar collecting in the barrels. When the gas and tar ceased to flow, the indication that the wood was completely charred, the cylinder was unsealed, and the charcoal was raked out into coolers. These were closed up, taken away, and the charcoal allowed to cool, when it was ready to be used in the manufacture of gunpowder.[17]

This method of producing charcoal remained essentially unchanged, but elements in the technology had been improved by the mid-nineteenth century. The wood was put into a sheet-iron cylinder with a moveable door, called Coleman's slip, which was lifted into the cast iron retort, and the latter was closed with a tight fitting door.[18] The retort was heated as previously described, and as the wood began to char, the gases and tar passed out of the slip through holes in one end and then out of the retort through a pipe into the furnace to be burned up as fuel. When the wood was completely charred, the slip was pulled out by tackle, lowered into a cooler, or extinguisher with a tight fitting lid, and kept there until all the fire was out. Then the charcoal was emptied into a receiver with a tight fitting cover to cool for two or three days, when it was ready for use.[19]

Grinding

Before the three constituent elements of gunpowder were combined, they were reduced to a fine powder. Originally, saltpetre was pulverized by dissolving a quantity of it in water in a kettle, boiling the water off, and working the precipitate with wooden paddles shod with copper until it had reached the requisite consistency.[20] Because this method was slow, tedious, and expensive and because so great a quantity of saltpetre was needed, rolling mills, similar to those used for incorporating (see below), were adopted at Faversham to grind the saltpetre. The older method remained in use, however, to pulverize saltpetre for certain laboratory purposes.[21] Sulphur and charcoal were originally ground in pestle mills, but rolling mills proved to be more effective.[22] Because the grinding of charcoal was so dirty, about 1850 Samuel Hall, an engineer, introduced a new mill which effectively controlled the diffusion of dust throughout the mill building. It consisted of a conical drum working vertically in a conical box.[23] Once the ingredients were ground, they were sifted to ensure their proper fineness; whatever did not pass through the mesh of the sieves was collected and ground again.

Mixing

The finely ground ingredients were weighed out in their proper proportions (31-1/2 pounds of saltpetre, 4 lbs. 3 oz. 3 dr. of sulphur, and 6 lbs. 4 oz. 13 dr. of charcoal) into a charge of 42 pounds, and given a rude, preliminary mixing. The weight of the charge was traditional, being the amount of powder that it was felt could be safely worked in a rolling mill. By 1850, some officials were arguing that 50 pounds was more appropriate, and at least at Waltham Abbey, this size of charge was adopted.[24]

An early method of mixing was quite simple. The ingredients were weighed into a charge tub, fitted with a circular board, from the underside of which projected a number of paddles. The board and paddles were rotated by a handle, like that of an augur, attached to its upper side, thereby mixing the charge.[25] A more sophisticated device was a barrel, which rotated in one direction around a horizontal spindle fitted with projections called flyers, which rotated in the other. After five minutes mixing in this barrel, the powder was poured into canvas bags, tied tightly to prevent the constituents from separating during movement, and taken to a small magazine for storage until it was required at the next stage of manufacture. These were called "green charges."[26]

Congreve, the younger, designed a very sophisticated method of mixing, but it is not clear that it was ever installed. Each ingredient was poured into a separate hopper, fixed contiguously to each other over an endless belt. Each was released in a stream onto the endless belt by the rotation of a wire brush fitted horizontally into a slot in the bottom of each hopper. The thickness of the stream was determined by the closeness of the fitting of the brush. The three components, released in their proper proportions onto the endless belt, were dumped by it into another hopper from which another brush forced the charge through a sieve, reducing it to a fine powder.[27]

Incorporating (Amalgamating)

The purpose of incorporating, which was regarded as the most important part of the manufacturing process, was to crush, grind, and mix together the ingredients into a hard mill-cake. Although it could be accomplished by hand with a pestle and mortar, to produce sizeable quantities stamp mills were developed to carry out the process mechanically. The charge was placed in wooden or stone mortars, dampened, and beaten for 24 hours by long pestles driven by a cam shaft. According to Smith, writing in 1779, there were 24 mortars in each mill, each capable of holding 20 pounds of mixture. The pestle, the beating end shod with copper, was 10 feet high and 4-1/2 inches broad.[28] The moistening agent could be water, vinegar, spirits of wine mixed with water, or urine, but Coleman in 1801 dismissed these latter agents and specified solely water. Eventually distilled water was used.[29]

Because stamp mills frequently exploded, they were prohibited in England (with certain specific exceptions) by act of Parliament in 1772.[30] In their place runner mills were adopted. Each of these consisted of a circular limestone bed, about 7 feet in diameter, on which rotated two limestone cylinders or runners from 5 to 7 feet in diameter and from 14 to 18 inches thick. The runners were mounted vertically on a common axle, which was attached to an upright shaft, connected to the machinery that turned them. Since they were positioned at different distances from the shaft, the paths of their rotation overlapped. Behind each runner followed a wooden scaper or plough, shod with leather and felt, which continuously distributed the charge underneath the runners. A sloping wooden border fixed around the bed, about 2 feet high, held the charge in, and a gun-metal "cheese," about 2 feet in diameter and 5 inches high, prevented the powder from working into the shaft hole at the centre. In the 1850s, iron beds and runners began to be substituted for those of stone, and by the 1860s, all the mills in the Royal Gunpowder Factory were iron.

The charge of 42, or later 50, pounds was spread evenly over the bed and dampened with water to give it sufficient body. The machinery was set in motion, the runners making seven or eight revolutions per minute, and the process was kept up for about 3-1/2 hours. Periodically a workman watered the charge, the frequency depending on the humidity in the mill house.

When the incorporating was completed, the mill-cake was shovelled from the bed into tubs and stored overnight in a small magazine. Later descriptions indicated that the cake was subjected to a proof to verify that it was properly mixed. A portion was broken: if it was a consistent, slate grey colour, some was ground up and fired in an eprouvette; another portion was flashed on glass. If the tests were satisfactory, the mill-cake could move on to the next stage in the process.[31]

Pressing

Pressing seems to have been a relatively late development in the manufacture of gunpowder. The brief accounts from 1750 to 1780 did not mention it, the cake proceeding directly from the mill to be granulated, or corned.[32] When Congreve, the elder, described the improvements in the manufacture of gunpowder since 1783, he indicated that special attention was paid to pressing. In 1801 Coleman also mentioned it.[33] Probably pressing was introduced in the mid-1780s.

The lumps of mill-cake were taken to the pressing house where they were put into a hand-press to be compacted into hard sheets of press-cake. A description, circa 1827, of the "Old Mode" was probably how it was done manually until the 1840s. Six layers of the mill-cake, alternating with thin copper plates, 1/8 inch thick, were put into a strong wooden box, about 3 feet long by 2 feet wide, the front of which opened sideways on hinges. The box was placed in a hand screw-press, and pressure was applied, compressing the mill-cake between the copper plates into very hard sheets of press cake, about 1-3/4 to 2 inches thick.[34]

Pressing continued to be an integral part of the process of gunpowder manufacturing, but certain innovations were introduced. In 1795 Joseph Bramah patented a hydraulic press, which in 1812 a committee of Royal Engineers recommended replace the screw-press. Its introduction, which may have been connected with improvements in granulating or corning made by Congreve, the younger, in 1816, seems to have been slow for the screw-press was still being used in the late 1820s. By the end of the 1840s, however, the hydraulic press was exclusively used in the Royal Gunpowder Factory at Waltham Abbey.[35]

To ensure that a more homogeneous, thinner, and harder press-cake was produced in the hydraulic press, the mill-cake was first broken down into a fine meal by passing it through a pair of brass rollers with coarse teeth. Then it was taken to the press-box, which in the 1850s and 1860s, was 2-1/2 feet square and 2 feet 9 inches thick. The box was placed in a vertical position, its top side hinged open, and removeable guides, gauged to receive 46 copper plates at intervals of 5/8 inch, were inserted along each side. When the copper plates, each 2 feet 5-1/2 inches square and 0.1 inch thick, had been put in place, about 800 pounds of meal were poured in, the guides removed, and the top side securely screwed down. The box was lifted by tackle into a horizontal position and put into a hydraulic press, where a force of about 70 tons per square foot was applied for 15 minutes. The box was lifted out of the press, opened, and the press-cake, which was about 3/10- to 1/2-inch thick, was separated from the copper plates. It was broken up by hand and stored in tubs in a small magazine for a day before proceeding to the next stage of manufacture.[36]

Granulating (Corning)

The process of granulating or corning that produced hard, integrated grains of gunpowder also underwent change and refinement over the years. In 1766, Adye wrote that the cake, which came directly from the stamp mill, was moistened (a variety of liquids could be used) and formed into balls about the size of an egg. Along with a wooden ball, these were put into a parchment sieve, punched with holes of the appropriate size. The sieve was shaken, causing the wooden ball to break up the powder balls and to force the powder through the holes into granules or corns.[37] In 1801, Coleman described a similar process, except that the cake was not dampened but broken up with mallets before being passed through the sieve. A number of these sieves were contained in large frames that were shaken mechanically.[38]

Although this method of corning continued to be used into the 1840s, in 1816 Congreve, the younger, installed a new granulating machine at Waltham Abbey, but it seems to have had only limited initial success. The press-cake was broken up and fed into two sets of toothed brass rollers, one above the other, the upper having coarser teeth than the lower. When the cake had been crushed by both sets of rollers, which rotated in unison, the resulting meal fell through a series of wire sieves of prescribed mesh which separated out the powder grains and the dust. Each sieve, which was set at an incline, deposited the powder or dust that remained on it onto a endless belt leading into a separate room. There the powder or dust was dumped into separate bins which were wheeled away when they were full.[39] Toward the end of the 1820s, this machine was reportedly in operation, but it needed constant repair because the teeth of the rollers lost their edges very quickly. When operating properly, it was capable of producing 36 barrels of powder a day, compared to eight barrels by the older method.[40]

By the early 1850s, perhaps before, Congreve's machine had been refined and completely adopted in the Royal Gunpowder factory at Waltham Abbey. The broken press-cake was placed in a hopper, which rose slowly by the motion of the machine, dumping its contents steadily onto an endless belt that carried the cake upwards to the first set of rollers. The cake passed through, not two, but three sets of rollers, each with finer teeth than the one before, and then fell through a series of three sieves of progressively finer mesh, by which large and fine grain gunpowder and dust were separated out into separate carriages. Any pieces, called chucks, which were too large to pass through the first sieve, were collected and recirculated through the machine. When the hopper was empty at the top of its upward passage, it rang a bell to signal the workmen to stop the machine and to wheel away the carriages of corned powder. In the 1860s, the only substantial change in the process was the addition of a fourth pair of rollers, of the same size as the third, presumably as an attempt to reduce the amount of chucks which had to be recirculated.[41]

Sifting, Dusting, and Glazing

Congreve's granulating machine and its successor combined the operations of corning and separating the sizes of gunpowder, but in the older process, sifting was done separately. The earlier descriptions were sufficiently vague that it is difficult to discover precisely what was done, but the intent, if not the details, is clear. The different types of gunpowder, as defined by grain size, were to be separated from each other and from the dust which was too fine for use. Then the gunpowder was glazed, that is, the rough edges of each grain were ground off and its surface given a hard shiny appearance. Separating and dusting could be accomplished in flat sieves, but reels, barrel-like frames covered with canvas or wire mesh in which the gunpowder was rotated, were being used in the 1790s. Because the axis of the reel was sloped, the powder was poured in at its upper end and rotated down its length, the dust falling through the mesh and the clean powder emerging at its lower end. Then the powder was glazed by rolling it in a barrel for about three hours. Either the barrel was a horizontal reel, or the glazed powder was subsequently reeled, since grinding off the rough edges of the corns would have produced more dust.[42]

With the introduction of the modified Congreve granulating machine in the late 1840s, the large grain (LG) and fine grain (FG) gunpowders produced by it were each treated slightly differently. The LG powder was loaded into a horizontal, cylindrical reel, covered with a canvas mesh, and the reel was rotated for about five hours, the dust falling through the mesh into the wooden case that enclosed the reel. When the process was completed, the gunpowder was both dusted and glazed and ready to be dried.

The FG powder was passed twice through a sloped reel, covered with a canvas mesh, to remove the dust. Then it was rotated for 5-1/2 or six hours in a large barrel to glaze it. Once more it was put through the sloped reel to remove the dust created during glazing, whereupon it was ready for drying.[43]

Drying

Although the gunpowder appeared dry, there was still some water in it, which it was necessary to remove. In Mediterranean countries or in India, drying could be accomplished by exposing the powder to the heat of the sun, but in England, a gloom stove was used. This was a room into one side of which projected a cast iron vessel, that was heated by a fire from the outside. The gunpowder was spread out on trays set into racks in the room and dried at a temperature of about 130°F. Although the fire was outside the drying room, there was some danger if powder were accidentally spilled onto the hot cast iron vessel.[44]

A safer method, which was introduced at Waltham Abbey in 1795, was to heat the room by steam circulated through pipes. (Steam drying had a secondary advantage of supplying distilled water for mixing with the charge during incorporating.) When the powder was dried, it was dusted in a horizontal reel to remove any dust produced by the heating. It was then ready to be packed in barrels for use as gunpowder.[45]

Powder Charges

From about 1700 to 1860, the service charge for artillery pieces was reduced generally. About 1725 it was 1/2 the weight of shot for brass guns; it varied for iron guns, increasing from about 2/5 the weight for a 42-pounder up to 3/4 the weight for a 1/2-pounder. Around 1750 the charge for brass guns remained unchanged, but it had fallen to some extent for iron guns; there was no change for the 42- to the 18-pounder (from 2/5 to 1/2 the weight of shot), but it had been reduced to 1/2 the weight of shot for the remaining calibres. By 1780 the service charge for both iron and heavy brass guns had been lowered to 1/3 the weight of the shot, although slight variations did occur; it was 1/3 or less for medium brass guns and even less for light guns. Although slight adjustments, both up and down, were registered until the end of the Napoleonic wars, this generalization remained essentially true. With the development of a greater diversity of iron guns after 1820, variations in service charge were more evident, but the heaviest charge was usually not more than 1/3 the weight of the shot. The service charge for the 32-pounder, for example, varied from 10 pounds for the 56 hundredweight gun down to 4 pounds for the very light 25 hundredweight gun.[46]

The Ordnance was able to reduce the service charge because gunpowder was becoming more powerful and of better quality. In 1783 at the end of the American Revolutionary War, William Congreve, the elder, found that in some line-of-battle ships, not 10 barrels of powder were fit for service.[47] Almost 20 years later, due in part to his efforts, "Gunpowder has been so much improved of late years ... that the experiments made with the old powder are now of little service..."[48] By the mid-1820s, the Respective Officers at Quebec were requesting the replacement of powder, not only because it was 25-years old, but because "...a great improvement has taken place in the manufacture of that article within these 20 years: such powder even in its original state was inferior to that made since...."[49]

The improvement in the quality of gunpowder was due to a number of factors. The development of the corning process, a significant innovation, had taken place well before the beginning of the eighteenth century. Despite this improvement, gunpowder produced by private manufacturers was still such a variable product that, in 1760, the Ordnance bought a gunpowder factory at Faversham. In 1787, it acquired a second at Waltham Abbey, and in 1794, a third was established at Ballincollig in Ireland. The control of these factories allowed the Ordnance to undertake improvements in manufacture and at the same time, by maintaining a high standard of comparison, to establish what today would be called quality control over the production of the private manufacturers.[50] In addition to government involvement, technological innovation made an important contribution to improved powder. The changeover from stamping to rolling mills in the 1770s, the introduction of the hydraulic press following the Napoleon wars, the perfecting of Congreve's granulating machinery by the 1840s, and other less important developments resulted in the production of a more consistent gunpowder. As well, more concern about the purification of ingredients and especially the discovery in the late 1780s that a purer charcoal could be produced by the distillation of wood in iron retorts than by the traditional method culminated in a more powerful and more durable product (for details see above).

Cartridges

Originally, a gunner used a ladle, a copper spoon attached to a wooden handle, to measure out and put down the barrel of a piece the proper charge of gunpowder. The slowness of this method and the danger inherent in having loose powder in a battery led to the introduction of cartridges in the early part of the seventeenth century. A cartridge was simply a bag of such a size and shape that it contained the appropriate charge of powder and could be rammed down the bore of the piece. At first, cartridges were used only for rapid firing, but by the middle of the eighteenth century, they were being made for all natures of ordnances.[51]

Since their introduction early in the seventeenth century, cartridges have been made of a variety of materials – different kinds of paper, parchment, bladders, canvas, linen, and woollens.[52] In England, paper and parchment were most commonly used by the first half of the eighteenth century, but their use was accompanied by certain difficulties. The bottoms of paper cartridges usually remained unburned at the bottom of the bore, and unless they were removed with a wadhook, an operation that delayed the working of the piece, they accumulated there and blocked the vent. Also, since the paper bottoms tended to retain fire, the bore had to be sponged out carefully lest the next cartridge put in be ignited prematurely. Parchment shrivelled up on firing and got into the vent, where it became so hard that it could not be cleaned out with the priming iron. A much more satisfactory material, flannel, had been adopted for the field service by mid-century, but paper cartridges remained standard issue both in the Royal Navy and for siege guns. Flannel burned more completely, or if fragments remained in the bore, they did not retain fire as readily as paper.[53]

In 1755, the Admiralty attempted unsuccessfully to introduce flannel cartridges into the naval service.[54] In 1778, Sir Charles Douglas, who had developed a flintlock for firing naval guns, recommended flannel cartridges, but with no success. A compromise of making the bottom of flannel was adopted at times. In his work on artillery, John Muller referred to parchment cartridges with flannel ends, and Douglas reportedly fitted out his ship, H.M.S. Duke, with flannel-bottom paper cartridges at his own expense. It is not clear precisely when the Royal Navy accepted flannel cartridges; one authority, Majendie, argued that they were in use in the navy by 1800, but it may have been after the Napoleonic wars before they were generally adopted at sea.[55] Both flannel and paper cartridges were listed as naval stores at Kingston, Upper Canada, in February 1813, but paper cartridges with flannel bottoms, as well as those of paper only, were still being sent out to the naval forces on the lakes in the spring of 1816.[56] It is certain, however, that by 1830 flannel cartridges were in common use for sea service.[57]

By the early 1790s (and probably before) both paper and flannel cartridges were appearing on lists of stores for the Royal Artillery in Canada. The field service used exclusively flannel, but both kinds appeared for garrison use, and during the war of

1812, paper cartridges with flannel bottoms also began to appear.[58] As early as 1795, these latter were being made in the Royal Laboratory.[59] As late as 1816, James noted in his dictionary:

> Cartridges for heavy guns are now partly made of cured paper only, and partly of cured paper with flannel bottoms.[60]

Paper was falling rapidly into disfavour. In 1819 a committee of artillery officers strongly recommended flannel cartridges, urging particularly their use with battering trains:

> in consequence of the many accidents that occur on Service from Paper Cartridges breaking whilst conveying through the Trenches, and also in the Batteries which very often occasion explosions...; to this may be added the safety that Flannel Cartridges afford in the service of the Guns, whilst keeping up the rapid and vigorous Fire so necessary in a Siege.[61]

By the mid-1820s paper cartridges were still in service for guns, but they were nearly obsolete. Henceforth cartridges were made of flannel.[62]

Although there is a paucity of information about the precise manner in which cartridges were manufactured in the eighteenth century, the general method seems clear; moreover, it did not change, except in detail, during the nineteenth. The proper dimensions, taken from a pattern, were marked on the material, and the cartridge was cut out. Then it was rolled on a former, much like a rolling pin, of the appropriate size and pasted (paper) or sewn (flannel) together, the edges overlapping. It is unclear how the bottom was closed. One notebook, describing the forming of paper cartridges for proof, seems to indicate that the bottom was choked, that is, tied off; after the cartridge was pasted and dried for 24 hours "...it will be ready for choaking [sic] & when choaked they are to be tied up in Bundles of 25 each..."[63] Another notebook of about the same time, circa 1800, seems to suggest that the bottom was glued; the paper was "...formed into Cartridges or Cylinders, using Wood Formers and Glue for securing the Joints and Bottom of each Cartridge & Cylinder..."[64] Perhaps proof cartridges were treated differently than service cartridges, but there is no obvious reason why they should have been. Presumably flannel cartridges could be either sewn or choked, but the few drawings extant indicate that they were sewn.[65]

When the cartridge was filled, especially with large amounts of powder, it tended to loose its shape. One method of counteracting this problem was to size the material before it was formed. John Muller advised:

> The best way of making flannel cartridges is, is [sic, in] my opinion, to boil the flannel in size; this will prevent the dust of the powder from passing through them, and renders them stiff, and more manageable; for without this precaution they are so pliable, that when they are large, and contain much powder, they are very inconvenient in putting them into the piece.[66]

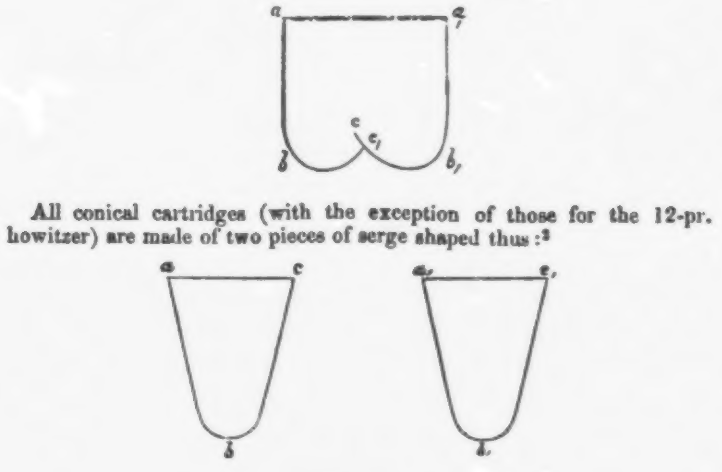
Paper was treated similarly. The process as practiced in the Royal Laboratory in 1797 was set down in some detail. The sheets of paper were first boiled briefly in an alum solution, and then taken out and dried. Once dried, they were submerged in a hot solution of alum and size and thoroughly washed in it. Presumably, the alum was a fixing agent to attach the size to the paper. Known as cured paper, the sheets were taken out and partially dried before being formed into cartridges or cylinders.[67]

No further references to the sizing of flannel have been found, but another method of strengthening flannel cartridges, by encircling them with hoops of worsted thread, was being used by the 1790s. In 1802, a notebook contained this description:

> Fill your Cartridges of what Nature soever they are with the proportionable quality [sic, quantity] of Powder and shake it

> down, then cut the Bag in a semicircular form at top and sew it up tight bringing the Worsted round the Cartridge in two Places, one at top and the other at bottom, giving several stitches of the Worsted over it to keep it down to the Cartridge to prevent it from slipping off.[68]

The number of hoops came to depend, in part, on the bulk, or rather, the length of the cartridge and, in part, on its use. In the naval service, the distant charge had three hoops, the full charge two, and the reduced and carronade charge one; in the land service, cartridges for heavy ordnance had three hoops, for light ordnance two, and for howitzers one.[69]



All conical cartridges (with the exception of those for the 12-pr. howitzer) are made of two pieces of serge shaped thus :[3]

Figure 207. Patterns for Cylindrical and Conical Cartridges. (Majendie, p. 151.)

The process of manufacturing flannel cartridges seems to have varied only in minor details from the 1820s (possibly earlier) to the 1860s.[70] The material, a kind of high quality flannel called serge, was hot pressed before use to stiffen it and to render it less liable to moth and other insect attack.[71] Two patterns of cartridge were cut from it — cylindrical, for most guns and the 12-pounder howitzer, and conical, for howitzers (except the 12-pounder), shell guns, and mortars.[72] The cylindrical cartridges were made from one piece of serge, but those of a conical shape were composed of two identical pieces. All cartridges for pieces above the 6-pounder gun, 12-pounder howitzer, and 5-1/2-inch mortar had seams with a 1 inch overlap, sewn with three rows of stitches; those for pieces below these calibres had a 3/4 inch overlap, sewn with two rows of stitches.

Once sewn into shape, the empty cartridge bag was then filled with the appropriate amount of powder.[73] The open end was then pleated closed with a needle threaded with three strands of worsted, the worsted was wound three times round the pleats, and the needle was passed five times alternately above and below the turns, thereby stitching the worsted in place. The surplus material above the turns of thread was cut off. The length of this choke varied. In the land service it varied with the calibre, but it was never to exceed half the diameter of cartridge; in the naval service, it was 1 inch in 1851, but subsequently it was shortened to 1/2 inch. In

1863, when the cartridges of both services were assimilated, a choke of 1 inch was adopted generally.

When the choking was completed, the needle was passed down through the cartridge to emerge from the seam at the appropriate distance for the number of hoops to encircle the cartridge. The strands of worsted were then brought tightly around the cartridge and stitched to it at two or three places to hold the hoop in place. Each additional hoop, if called for, was made in the same way.[74]

Until 1863, land and sea service cartridges were marked differently. On the side of the former, the nature of the piece and the number of pounds of powder were printed in black. Because there were three sizes of charge for each gun in naval service, these cartridges were marked differently:

Distant - in black, with calibre and weight of piece, number of pounds of powder, and letter D;
Full - in blue, with calibre and weight of piece, number of pounds of powder, and letter F and a ball;
Reduced - in red, with calibre and weight of piece, number of pounds of powder, and letter R and a ball.

The carronade cartridge was marked similarly to the full charge.[75] In 1863, it was decided that all cartridges were to be painted in black letters with the calibre of the piece and the weight of the charge; howitzer, mortar, and carronade cartridges also bore the letters "How.," "Mor.," or "Car." The only exceptions were the 10-pound cartridges for the 8-inch guns of 65 and 60 hundredweight and the 32-pounder guns of 58 and 56 hundredweight; the letter D and the weight of gun were also marked.[76] As well, all cartridges had stamped on their bottoms the initial letter or monogram of the station at which they were filled, except those filled by the Royal Artillery which remained unmarked.[77]

PROJECTILES

Solid Round Shot

The most common, simplest, and probably oldest projectile fired from smoothbore ordnance was solid round shot. Since this missile had been thrown from the pre-gunpowder artillery of the ancient civilizations, it was a natural progression to use it in the newly invented guns. Initially the shot was of stone, but this material proved too brittle to withstand the explosive force of gunpowder. Other substances were tried. Lead was appropriately dense but too soft. Wrought iron was very strong but difficult to work and expensive. Only cast iron united the "... essential qualities of hardness, strength, density, and cheapness."[1]

Solid shot was a most effective weapon. It was very destructive when fired against material – gates, walls, gun-carriages, wagons. It was equally ruinous against men and horses, particularly if they were massed in column or if they could be taken in enfilade, when one ball could kill or maim many. It is difficult to say precisely when it was introduced into use in England, but by 1700 it was the most popular projectile of the artillery, whether field, siege, or garrison.[2]

By 1700, or shortly thereafter, artillery *matériel* in England was undergoing a reorganization. The older practice of giving fancy names to pieces (such as fierce birds or animals) was dropped, and guns became known by the weight of the shot that they fired. The sequence of weights of shot adopted, 1/2, 1, 1-1/2, 2, 3, 4, 5-1/4, 6, 9, 12, 18, 24, 32, and 42 pounds, remained in effect more or less until after the Napoleonic wars. (The 5-1/4-pounder gun remains a mystery, but it had vanished by the middle of the eighteenth century.) Since the diameter of a cast iron round shot varied directly as the cube root of its weight, and since it was known that a 9-pound ball had a diameter of 4 inches, it was possible to find the diameter of any weight of round shot by using the formula[3]

$$\sqrt[3]{\frac{9}{4}} = \sqrt[3]{\frac{\text{given weight}}{\text{diameter}}}$$

The diameter of the bore or calibre of a gun was determined by adding the windage to the diameter of the shot. Windage, which is the difference between the diameters of the bore and the shot, was usually expressed as a fraction of the diameter of the shot. Colonel Albert Borgard, who was designing guns between 1716 and 1725, specified a slightly different windage, and therefore a different calibre, for his brass and iron guns, even though they fired the same weight of ball: for brass guns 1/31 and for iron guns 1/21 of the diameter of the shot.[4] Subsequently it was set at 1/20 of the diameter of the shot for both brass and iron pieces.[5] Windage was necessary to allow for inaccuracies in the casting both of the bore and of the shot, for accumulation of rust or paint on the shot, for the fouling of the bore during quick or continuous firing, for the expansion of the shot if it was heated, and for the thickness of the tin straps used to attach the ball to its wooden bottom or *sabot*.

Since it was technologically impossible to cast a ball exactly to the diameter required, a certain element of error was allowed the manufacturer. It has not been discovered what allowance Borgard made, but subsequently it was 1/3 of the windage. This was known as the high gauge; the prescribed diameter of the shot was the low gauge.[6] These gauges were metal rings with handles, through which, in the case of the high gauge, the shot must pass, and in that of the low, it must not pass.

Using these formulae, we can deternmine the diameter of the shot (and of the low gauge), the windage, the calibre of the gun, and the high gauge from 1716 to 1825. (The figures are rounded to the nearest 1/1000 inch.)

		Windage			Calibre			High Gauge	
		Borgard		post-	Borgard		post-	Borgard	post-
Pounder	Diameter of shot	Brass 1/31 diam.	Iron 1/21 diam.	Borgard 1/20 diam.	Brass	Iron	Borgard		Borgard
1/2	1.526	.049	.073	.076	1.575	1.599	1.602		1.551
1	1.923	.062	.092	.096	1.985	2.015	2.019		1.955
1-1/2	2.201	.071	.105	.110	2.272	2.306	2.311		2.238
2	2.423	.078	.115	.121	2.501	2.538	2.544		2.463
3	2.773	.089	.132	.139	2.862	2.905	2.912		2.819
4	3.053	.098	.145	.153	3.151	3.198	3.206		3.104
5-1/4	3.342	.108	.159	.167	3.450	3.501	3.509		3.398
6	3.494	.113	.166	.175	3.607	3.660	3.669		3.552
9	4.000	.129	.190	.200	4.129	4.190	4.200		4.067
12	4.403	.142	.210	.220	4.545	4.613	4.623		4.476
18	5.040	.163	.240	.252	5.203	5.280	5.292		5.124
24	5.547	.179	.264	.277	5.726	5.811	5.824		5.639
32	6.105	.197	.291	.305	6.302	6.396	6.410		6.207
42	6.684	.216	.318	.334	6.900	7.002	7.018		6.795

A comparison of these figures with those in tables in various notebooks and manuals from 1750 to 1821 reveals only minor differences.[7] Muller put the diameter of a 3-pound shot at 2.775 inches and of a 6-pound shot at 3.498 inches, figures which were repeated in subsequent tables. In 1764 the 1/2-pounder gun was said to have a calibre of 1.58 inches and fired a shot of a diameter of 1.505 inches, but a later notebook from the 1790s agreed with the above table. Except for the 1/2-pound shot, the diameters of the cast iron solid round shot did not vary significantly from 1716 to 1825.

Given the relationship between the nominal weight of a shot and its diameter, this observation is hardly surprising. But the problem of excessive windage, which much exercised the minds of artillerists during this period, could be solved either by reducing the diameter of the bore or by increasing the diameter of the shot. It was clear that if the windage was reduced, both the range and accuracy of artillery practice could be improved. Less of the explosive force of the propellant would escape around the ball, and since the ball would bounce less coming along the bore, it would deviate less in flight. Benjamin Robins had made this point in his New Principles of Gunnery in 1742, and John Muller had reiterated it in his A Treatise of Artillery in 1757.[8] The introduction of the carronade in 1779 recognized in practice the value of reduced windage, for the diameter of the calibre of a carronade was slightly less than that of the corresponding gun. Dr. Charles Hutton, professor of mathematics at the Royal Military Academy, conducted numerous experiments on windage during the 1780s that illustrated the correctness of the views of theorists like Robins and Muller, but nothing was done to reduce the windage either by decreasing the diameter of the gun's calibre or by increasing the shot's diameter.[9]

In June 1817 Colonel Sir Howard Douglas, then Inspector-General, Royal Military College, submitted a paper to the Master-General of the Ordnance in which he recommended reducing the windage by increasing the diameter of the shot. He argued further that there was no reason for determining the windage as a proportion of the diameter of the shot, since, except for expansion due to heating for hot shot, the reasons for windage bore no proportional relationship to the size of the shot. Instead he suggested a constant figure. The Select Committee of the Board of Ordnance was sufficiently impressed by Douglas' views that it conducted a series of experiments to determine if a reduction of windage was justified. Initially it recommended that the windage of field guns (6-, 9-, and 12-pounders) be reduced to 0.1 inch, and subsequently, after a series of experiments with an iron 24-pounder, that the windage of iron ordnance be decreased to 0.15 inch.[10]

Although the officers of the Royal Artillery were in agreement, their colleagues in the Royal Navy would not support their views. The naval authorities saw a greater potential for shot stored on shipboard to rust. Given the standard naval tactics of close action, they were less concerned with accuracy than with rapidity of fire. Unless the carronades were all bored out to the diameter of the bore of guns, they feared that there would be confusion resulting from having different sized shot for the same calibre of gun and carronade. Lastly, they felt that a gun could not stand the strain of double shoting (a common naval practice) with the proposed diameter of shot. In deference to their naval colleagues' opinions, the Royal Artillery officers withdrew their recommendations concerning the windage of iron ordnance, but even the proposal to increase the diameter of the shot of field guns, which remained, was not implemented.[11]

In 1825, for reasons not clear from the sources available, the windage of guns was decreased by the introduction of a new series of gauges. The high gauge for the 1-, 1-1/2, 2-, and 4-pound shot; both the high and low gauge for the 3-, 6-, and 9-pound shot; and the low gauge for the 12- to 42- pound shot were increased.[12] The windage was calculated from the mean of the high and low gauge, rather than from the low gauge as before. (The 1/2-pound shot did not fit the pattern, but information about it is incomplete and confused.) The following table outlines the changes.[13]

Pounder	Calibre in.	High Gauge in.	Low Gauge in.	Mean Gauge in.	Mean Windage in.
1/2	1.602	1.549	1.519	1.534	0.068
1	2.019	1.969	1.923	1.946	0.073
1-1/2	2.311	2.269	2.201	2.235	0.076
2	2.544	2.484	2.423	2.4535	0.0905
3	2.913*	2.833	2.803	2.818	0.905
4	3.204*	3.124	3.053	3.0885	0.1155
6	3.668*	3.568	3.532	3.550	0.118
9	4.200	4.100	4.060	4.080	0.120
12	4.623	4.476	4.432	4.454	0.169
18	5.292	5.124	5.074	5.099	0.193
24	5.823*	5.639	5.584	5.6115	0.2115
32	6.410	6.207	6.147	6.177	0.233
42	7.018	6.795	6.729	6.762	0.256

* These are calibres given in 1821 and not those computed for the table previously given. The differences are minor, 0.001 or 0.002 inch.

These gauges remained the standard until 1843 when the Select Committee of the Board of Ordnance once again considered the question of the windage of brass field guns (3-, 6-, 9-, and 12-pounders) and recommended that the windage of 3-pounders be set at 0.09 inch and of 6-, 9-, and 12-pounders at 0.1 inch. This was to be accomplished by adjusting the gauges according to the recommendations made by the Select Committee in 1818. On 27 March 1843 the Master-General and Board sanctioned the following new gauges:[14]

Pounder	Calibre in.	High Gauge in.	Low Gauge in.	Mean Gauge in.	Mean Windage in.
3	2.913	2.8380	2.8080	2.823	0.09
6	3.668	3.5855	3.5505	3.568	0.1
9	4.200	4.1175	4.0825	4.100	0.1
12	4.623	4.5405	4.5055	4.523	0.1

This indicates that there were two sets of gauges for 3-, 6-, 9-, and 12-pound shot, one to measure shot for brass field pieces and another to measure it for iron guns. This may have been true for a short period, but by the 1840s iron 3-pounders were probably no longer in service, iron 6- and 9-pounders were used only for saluting, and iron 12-pounders served occasionally in special situations. By 1857 the shot gauges for 12-pound shot and lower for iron guns have vanished completely. By then the sets of gauges issued incorporated those of 1825 for shot for iron guns above the 12-pounder, those of 1843 for shot for field pieces, and a new set for shot for the new iron guns (42-, 56-, and 68-pounders) introduces since 1825.[15]

Pounder*	High Gauge in.	Low Gauge in.	Mean Gauge in.
3+	2.838	2.808	2.823
6+	3.585	3.551	3.568
9+	4.117	4.083	4.100
12+	4.540	4.505	4.5225
18	5.124	5.074	5.099
24	5.639	5.584	5.6115
32	6.207	6.147	6.177
42	6.795	6.735	6.765
56	7.510	7.450	7.480
68	7.950	7.900	7.925

* For calibres, see individual guns. Those of some guns, especially 32-pounders, vary by this time.

+ These are very minor variations between the dimensions of the gauges listed here and those listed for 1843, of no significance.

Shells

A shell was a hollow globe, usually of iron, filled with gunpowder that was exploded by a fuze inserted into its casing. Although there were references to the use of shells as early as 1376, it is questionable if these were other than reports of their occasional and probably imperfect employment. Probably in 1624, during the siege of Grol, Prince Henry of Nassau first used shells extensively, and his success resulted in their adoption by the other warring European powers. Initially shells, or bombs as they were also called, were hurled from mortars at high angles during sieges, but howitzers, which were really light, portable mortars, were developed to allow their use in the field. Also, Vauban's successful innovation of ricochet firing of shot during sieges was adapted to the firing of shells from howitzers.[16]

Although shells undoubtedly were included among British munitions during the first half of the eighteenth century, no details of their construction have been found. For the period from about 1750 into the 1790s most of the material about shells is contained in four manuscript notebooks held by the Royal Artillery Institution Library, Woolwich. From these sources three tables of dimensions and weights can be put together, two of which can be dated and seem to indicate a progression, while the third raises a problem. A table of shell dimensions dated September 1753 occurs in a manuscript notebook attributed to Samuel Glegg; a table, identical except for one minor variation, which seems to be a transpositional error, appears in Thomas Walton's notebook, which was probably compiled in the 1780s.[17]

Exterior Diameter in.	Interior Diameter in.	Thickness of Iron		Diameter of Fuze Hole		Weight		
		at Top in.	at Bottom in.	at Top in.	at Bottom in.	lbs.	ozs.	parts
12.75	8.760	1.593	2.390	1.837	1.696	194	4	339
9.75	6.700	1.220	1.830	1.570	1.450	87	7	302
7.75	5.541	0.968	1.331	1.219*	1.127	43	14	041
5.54	3.896	0.692	0.951	0.894	0.826	16	0	389
4.40	3.094	0.549	0.755	0.832	0.769	8	4	125

* Walton, 1.291. Walton appears to have made an error in copying.

In both Glegg's and Walton's tables the thickness of iron at the top of the shell was said to be 8/64 and at the bottom 12/64 of the diameter of the shell. But the figures actually given for the bottom thickness of the three smallest shells was 11/64 of the diameter. There is no obvious explanation of this discrepancy, but the figures given should probably be accepted, since in all three cases they add up to the exterior diameter of the shell.

A second table of dimensions, different from the above, can be put together from three sources --- from the Glegg notebook, from a practice book of 1760, and from a manuscript notebook of 1766.[18] The three sources were in general agreement, but there were slight variations in individual measurements. (The actual figures were given as fractions but have been converted to decimals for comparison to the table above.)

Exterior Diameter in.	Interior Diameter in.	Thickness of Iron at Top in.	at Bottom in.	Diameter of Fuze Hole[1] at Top in.	at Bottom in.	Weight lbs.	ozs.	parts
12.75(S.S.)						200	0	0
12.75(L.S.)	9.875	1.250[2]	1.625[3]	1.750	1.4375	168	0	0
9.75	7.250	1.000	1.500	1.625	1.3125	84	8	0
7.75	6.375	.625	.750	1.625[4]	1.1875	40	7	0
5.50	4.125	.500	.806	.875[5]	.8125	14	9	0
4.42	3.625	.400	.625	.750	.6875	7	7	0

[1] The fuze hole was conical, i.e. the top diameter was greater than that of the bottom. In the three tables consulted to make up this table these measurements were confused, sometimes the top, sometimes the bottom diameter being greater. They have been rearranged so that the top diameter is always greater.

[2] RAI, Adye (1766), op. cit., p. 37 gave 1.375 in.

[3] Ibid. gave 1.5 in.

[4] Ibid. gave .625 in.

[5] Ibid. and RAI, Glegg, op. cit., p. 73, gave .875 in., as above, but RAI, "Practice Book 1760," gave 1.875 in., which must be an error.

Although there are problems with this table, it indicates that there was a change in shell specifications between 1753 and 1760; the shell had become lighter, thinner skinned, with a larger interior capacity to contain more powder.[19]

There is a third table of shell dimensions in Glegg's notebook, however, which differs from both these tables.[20]

Exterior Diameter in.	Interior Diameter in.	Thickness of Iron at Top in.	at Bottom in.	Diameter of Fuze Hole[1] at Top in.	at Bottom in.	Weight lbs.	ozs.	parts
12.75	8.3125	1.75	2.70	1.75		200	190	195
9.75	6.000	1.50	2.25	1.50		93	85	89
7.75	5.125	1.05	1.57	1.25		42	38	40
5.50	4.000	.57	.87	1.85[2]		15-1/4	14	14-5/8
4.40	3.250	.46	.69	.75		8	7	7-1/2

[1] Only 1 dimension was given.

[2] This must be an error for 0.85 in.

It is difficult to know what to make of this table. Its position in Glegg's notebook on page 69, between the 1753 table (p. 4) and the table similar to that in the

1760 practice book (p. 73), suggests that it should be dated sometime between 1753 and 1760, but it seems unlikely that there would be three different specifications developed within seven years. The solution to the problem remains a mystery. Similarly, it is not clear why Walton's notebook contains only the 1753 specifications; had those of the 1760 trials been found wanting and had the Ordnance reverted to the earlier dimensions?

Until at least 1780 and probably later shells continued to be manufactured with a greater thickness of metal opposite the fuze hole. Two reasons were given for this construction.

> ... the first is, that they are thereby better enabled to resist the shock or impression of the Powder that discharges them; the other, that the Shell always falling with y^e heaviest part undermost, there will be no danger of the fuze being extinguish'd or broke off by the fall, should it come to y^e Ground before the Explosion.[21]

John Muller had scoffed at both these reasons.

> ... if the shells were everywhere equally thick, and of the same weight as those above-mentioned [of his design], the blast of powder lodged in the chamber would hardly be able to break them; and as to the fuze falling uppermost or not, that is of no detriment, since the composition of fuzes is such, that nothing but an absolute stoppage from the air is able to choak them; for they burn in water as well as any other element; for which reason I would make them everywhere equally thick, because they would burst into a greater number of pieces.[22]

Muller's advice was not quickly adopted. As late as July and August 1792 the Ordnance conducted experiments to test old and new pattern shells in which the thickness of metal was variable.[23] In the 1801 edition of the Bombardier and Pocket Gunner, however, Adye noted:

> Shells were till lately made thicker at the bottom than at the fuze hole; but are now cast of the same thickness throughout, and are found to burst into a greater number of pieces in consequence.[24]

Probably between 1792 and 1801, therefore, the ordnance decided to construct shells with a skin of constant thickness.

A second innovation of the last two decades of the eighteenth century was the development of shells to be fired from guns. Previously shells had been fired with high trajectories and small charges from mortars and howitzers. Fired horizontally from guns they tended to break up and explode in the barrel.[25] While there is evidence that the Royal Artillery experimented with firing shells horizontally in Canada in 1776,[26] a major breakthrough was made during the siege of Gibraltar, 1779-83, when the British succeeded in throwing 5-1/2-inch mortar shells out of their 24-pounder guns. By 1798 an artillery notebook listed gauges for shells to be fired, not only from mortars and howitzers, but also from guns and carronades. Interestingly, the high gauges for carronade shells were slightly smaller than those for shells for the corresponding calibre of gun, probably to compensate for the slightly smaller bore diameter of the carronade.[27]

According to the circa 1798 notebook the dimensions presumably of the high gauge for shells of guns and carronades were:[28]

Nature pdr.	Guns in.	Carronades in.
68		7.83
42	6.795	6.67
32	6.20	6.07
24	5.63	5.50
18	5.11	4.955
12	4.45	4.315

It is not clear why only the dimensions of the one gauge were given; presumably the gauges for shot could be used for the low gauge.

Although Adye mentioned in his 1801 manual that shells could be fired from guns and carronades, it was not until the 1813 edition that he supplied tables of dimensions.[29]

Guns Nature	Diameter		Diameter of Fuze Hole		Thickness of Metal
	exterior	interior	outside	inside	
pdr.	in.	in.	in.	in.	in.
42	6.684		4.404		0.894
32	6.105		4.005		0.894
24	5.547		3.767		0.893
18	5.05	3.4	0.832		0.76
12	4.4	2.8	0.832		0.769

Carronades Nature	Diameter		Thickness of Metal
	exterior	interior	
pdr.	in.	in.	in.
68	?	?	?
42	6.64	4.36	1.14
32	6.05	3.95	1.35*
24	5.48	3.48	1.00
18	4.935	3.235	0.85
12	4.295	2.695	0.98*

* These appear to be wrong: 1.05 and 0.8 respectively would be correct if the exterior and interior diameters are correct.

Adye's exterior diameter appear to be ideal; the diameters of the gauges listed in 1798 were always higher, that is those of the high gauge.

A third development during this period, although this is not as clear, may have been the decrease in windage by the slight enlargement of the diameters of mortar shells. Excessive windage was one of the problems being investigated by the committee conducting the experiments in 1792 previously referred to. They concluded that it should be reduced to 0.15 inch for 13-, 10-, and 8-inch shells and to 0.1 inch for the smaller natures and, moreover, that this reduction should be achieved by increasing the diameters of the shells.[30] A table dated 1798 in a manuscript notebook indicated that the low gauge for mortar shells was greater than the diameters previously given for mortar shells.[31] Unaccountably, Adye in the various editions of the Bombardier and Pocket Gunner up to 1813 continued to list dimensions for mortar shells which allowed a windage of 0.25 inch.[32]

The table dated 1798 gave the following dimensions of the gauges for mortar and howitzer shells.[33]

Nature in.	High Gauge in.	Low Gauge in.
13	12.88	12.80
10	9.88	9.80
8	7.88	7.80
5-1/2	5.54	5.48
4-2/5	4.42	4.38

In the 1801 and 1813 editions of his manual Adye provided the following information on mortar and howitzer shells.[34]

Nature	Weight			Diameter	Diameter of Fuze Hole		Thickness of Metal
					outside	inside	
in.	cwt.	qr.	lb.	in.	in.	in.	in.
13	1	3	2	12-3/4	1.837	1.696	2.05
10		3	9	9-3/4	1.57	1.45	1.575
8		1	11-1/2	8-3/4	1.219	1.127	1.2
5-1/2			15-1/4	5-1/4	0.894	0.826	0.822
4-2/5			8	4-1/5	0.832	0.769	0.653

By 1820 there seems to have been some minor adjustments to the size of the fuze holes and the thickness of the skins (depth) of shells for mortars and howitzers. According to a "memorandum furnished by Lieut. Colonel Bingham from Laboratory" the dimensions of fuze holes were:

Nature	Diameter of Fuze Hole top in.	bottom in.	Depth in.
13 in.	1.84	1.7	2.1
10 in.	1.61	1.5	1.6
8 in. or 68-pdr.	1.22	1.13	1.3
5-1/2 in. or 24-pdr.	0.9	0.84	0.85
4-2/5 in. or 12-pdr.	0.82	0.77	0.7

These changes continued when in 1825 a new series of gauges for both shot and shell was introduced into the service. The dimensions of the various shells were:[35]

Mortars and Howitzers

Nature	Weight			Diameter		Diameter of Fuze Hole		Thickness of Metal
				High	Low	outside	inside	
in.	cwt.	qr.	lb.	in.	in.	in.	in.	in.
13 in.	1	3	4	12.88	12.8	1.84	1.7	2.1
10 in.		3	11	9.88	9.8	1.61	1.5	1.6
8 in.		1	13 1/4	7.95	7.85	1.22	1.13	1.3
5-1/2 in. or 24-pdr.			15	5.62	5.57	0.9	0.84	0.85
4-2/5 in. or 12-pdr.			7 1/2	4.476	4.432	0.82	0.77	0.7

Guns and Carronades

Nature		Weight		Diameter		Diameter of Fuze Hole	
				High	Low	outside	inside
in.	qr.	lb.	oz.	in.	in.	in.	in.
10 in.	2	14		9.9	9.84	1.22	1.1
68-pdr.	1	5	6 1/4	7.95	7.85	1.22	1.1
42		20		6.795	6.729	1.22	1.1
32		15	4 1/4	6.207	6.147	1.22	1.1
24		11	15	5.62	5.57	.89	.77
18		9	1 1/4	5.124	5.074	.89	.77
12		5	15	4.476	4.432	.89	.77
9		4	10	4.1	4.06	.89	.77
6		3	2	3.568	3.532	.89	.77

The changes in shell diameters over the next 30 to 35 years concerned mainly those shells for the new guns which were developed in the 1830s and '40s – the new 42-pounders, the 56- and 68-pounders, and the shell guns. The dimensions of shells for the 32-pounder down to the 6-pounder remained unchanged during this period.[36] In 1857 the following dimensions were given for the shells of the new guns:[37]

Nature	Diameter		
	high in.	low in.	mean in.
10 inch	9.88	9.8	9.84
68-pdr., 8 inch	7.9	7.82	7.86
56-pdr.	7.51	7.45	7.48
42-pdr.	6.795	6.745	6.77

Ten years later, minor variations, the reasons for which are obscure, were noted in the 10-inch and 42-pounder gauges:[38]

Nature	Diameter		
	high in.	low in.	mean in.
10 inch	9.88	9.82	9.85
42-pdr.	6.795	6.735	6.765

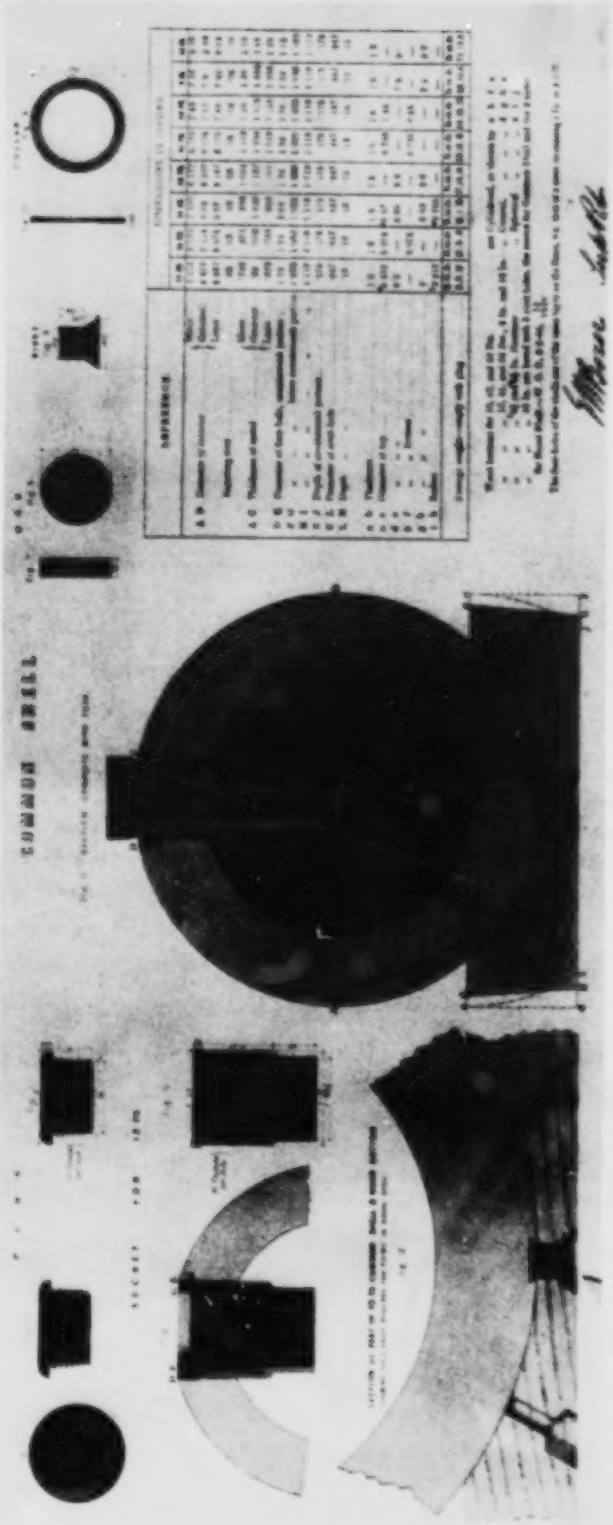


Figure 208. Common Shell. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate 34, July 1864.)

In the 1840s a manual by Straith gave a separate table for carronade shells:[39]

Nature	Diameter high in.	 low in.	 mean in.
68	7.9	7.8	7.85
42	6.79	6.72	6.755
24	5.63	5.58	5.605
18	5.12	5.07	5.095
12	4.47	4.4	4.435

For some reason the 32-pounder was left out. In 1862 Griffiths printed a slightly different table including the 32- and 6-pounder and showing minor changes for the 68- and 12-pounder; the other calibres remained unchanged.[40]

Nature	Diameter high in.	 low in.	 mean in.
68	7.95	7.9	7.925
32	6.2	6.14	6.17
12	4.47	4.3	4.385
6	3.56	3.53	3.545

The authoritative works of Majendie and Lefroy in 1867 did not mention separate dimensions for shells for carronades.[41] Considering how near to the diameters of gun shells they were, the question might be raised if in practice this distinction was actually made.

The diameters of mortar shells, except for that of the 8-inch shell, remained constant from 1825 to 1857.[42] The 8-inch shell was made slightly smaller, presumably to match the 68-pounder or 8-inch gun shell:

high in.	low in.	mean in.
7.9	7.82	7.86

Between 1857 and 1867 there was a minor change in the low gauge of the 10-inch shell, increasing from 9.8 to 9.82 inches, the same as the common and naval shell.[43]

The size of fuze holes of common shells remained constant throughout the 1830s and 1840s.[44]

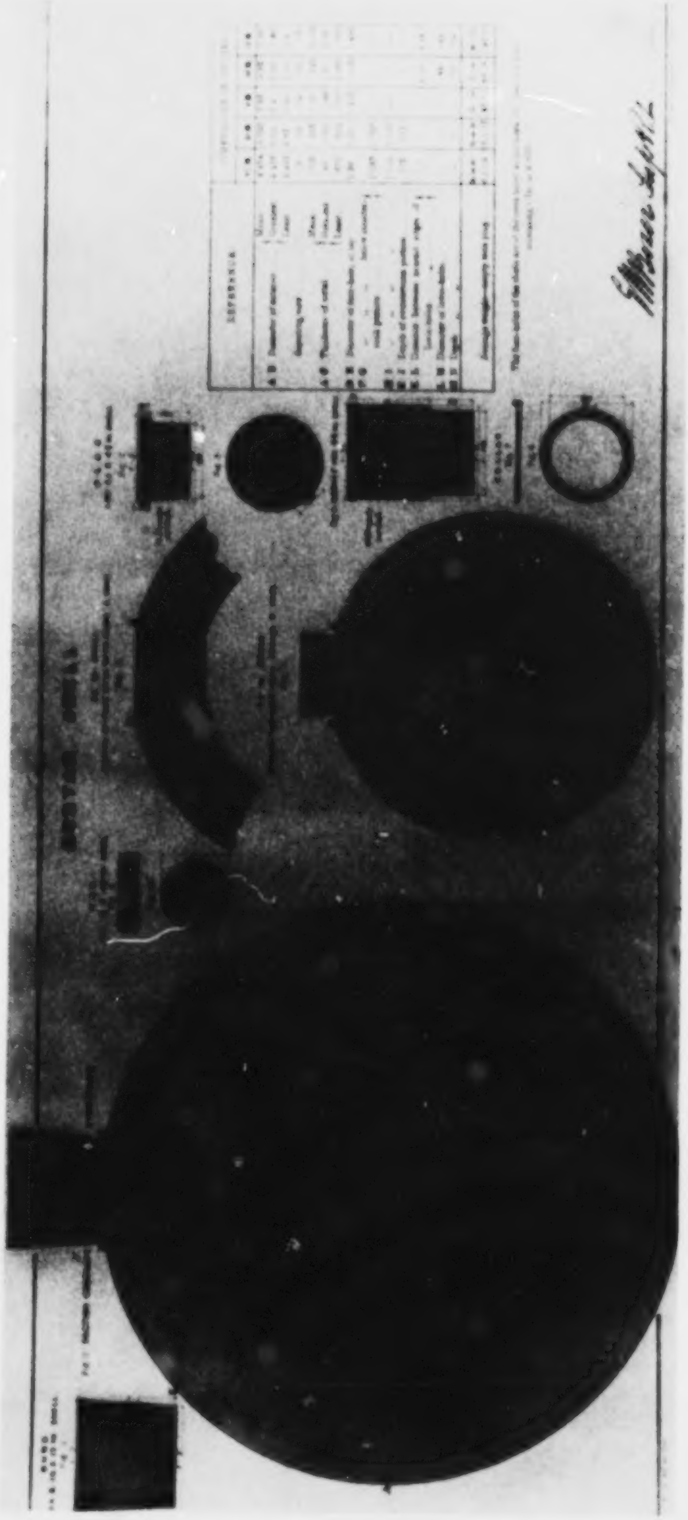


Figure 209. Mortar Shell. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate 35, August 1864.)

Nature	Diameter	
	Outside in.	Inside in.
10 in. to 32-pdr.	1.2	1.1
24-pdr. to 6-pdr.	.89	.77

In 1849 Boxer began his series of modifications in fuze design, and in 1855, with the introduction of his "large cone" fuze, the fuze hole for all calibres of shells wasreduced to one diameter on the outside. It remained conical in shape, pitched at 1 inch in 9.375 inches. In 1854 or 1855 the Board of Ordnance ordered that it be tapped to hold the wooden fuze more securely. Originally this tapping may have been no more than roughing, but in 1856 metal screw plugs were adopted in place of cork plugs.[45] The hole was tapped with a right handed thread, 14 threads to 1 inch, sufficiently along its length to take the screw plug. In 1860 the hole was countersunk to bring the top of the plug flush with the surface of the shell so that it could be used as hollow shot. In 1861 the tapping of the fuze hole was continued over its entire length to take Pettman's fuze, and shells so tapped were to have + marked on their plugs to indicate this capability. The fuze hole of the 12-pounder shell was treated differently because in many instances the fuze had been blown out of the shell by the explosion of the bursting charge without the shell fragmenting.[46] To give the fuze more support the fuze hole was fitted with a gun metal bush which extended into the interior of the shell. Thus, by 1867 the dimensions of fuze holes in common shells were:[47]

Nature	Diameter		
	Countersunk in.	Below Top in.	Countersunk Bottom in.
10 in.	1.32		0.88
8 in. or 68-pdr.	1.32	high	0.875
56-pdr.	1.32	1.034	0.89
42-pdr.	1.32		0.902
32-pdr.	1.32	low	0.913
24-pdr. or 5-1/2 in.	1.32	1.024	0.925
18-pdr.	1.32		0.937
12-pdr. or 4-2/5 in.	1.32	1.295*	1.225*

* Before bushing

The size of the fuze holes of mortar shells had a similar history. Most sources in the 1840s gave the following dimensions, although Griffiths gave slightly different figures.[48]

Nature	Diameter Outside in.	Diameter Inside in.
13 in.	1.837	1.696
10 in.	1.61	1.5
8 in.	1.22	1.13
5-1/2 in.	.9	.84
4-2/5 in.	.82	.77

The development of Boxer's new mortar fuze in 1855 necessitated a change in the diameters of the fuze holes.[49]

Nature	Diameter Outside in.	Diameter Inside in.
13 in.	1.484	1.25
10 in.	1.484	1.309
8 in.	1.411	1.259

(The 5-1/2- and 4-2/5-inch mortars threw the same shell as the 24- and 12-pounder guns.) The hole was not countersunk, but it was tapped part way down, initially to secure the fuze more firmly, but after 1856 to take a white metal screw plug. In 1860 this plug was discontinued, and beeswaxed cork plugs that had previously been used, were reintroduced.[50]

Mortar shells differed from common shells in not being attached to wooden bottoms; hence they had no rivet holes drilled in them.[51] As well, because of the weight of 13- and 10-inch shells, they were equiped first with lugs and then, after January 1856, with lewis holes to aid in their loading. The lugs, which were two projecting loops of wrought iron cast into the shell on each side of the fuze hole, had been the traditional device. Muller described them in the eighteenth century:

> They are two handles of hammered iron fixed in the mould when they are cast, which fasten to the shell, and serve to lay hold on when the mortar is to be loaded thereby, as likewise to carry them from one place to another.[52]

The lugs were often broken off during transport, and they necessitated that the shells be cleaned by hand, a more expensive process than milling or rotating them in large iron drums. In 1856 lewis holes were ordered drilled in the 13- and 10-inch shells in the same position as the lugs and inclined toward each other; into these two holes lewis hooks fitted to aid in lifting the shell into the mortar.[53]

Along with the development of new naval guns and metal fuzes in the 1830s, shells for the 10-inch, 8-inch or 68-pounder, and 32-pounder guns were prepared for the exclusive use of the Royal Navy. Initially, perhaps, the only distinction between these naval shells and common shells was the tapping of the fuze hole to receive the screw-in metal time fuze. Since dimensions of naval shells have not been found for the 1830s, it is impossible to say if their dimensions varied then from those of common shells, but by the end of the 1840s both the 10- and 8-inch shells were slightly larger and thinner skinned than the equivalent common shells. The 32-pounder naval shell was identical to the common shell.

Nature	Dimensions			Thickness of Metal
	high in.	low in.	medium in.	mean in.
10 in.	9.88	9.82	9.85	1.35
8 in./68-pdr.	7.95	7.9	7.925	1.35
32-pdr.	6.207	6.147	6.177	1.034

These dimensions remained constant to the end of the smooth-bore era.[54]

In the 1830s the fuze hole was tapped to take the metal fuze, but because of rust and the resulting increased friction when the fuze was screwed in, accidental explosions occurred. Consequently, by about 1843, gun metal bushes were fixed into the fuze holes.[55] Originally the holes were probably conical and of the same diameter as those of common shells;[56] diagrams toward the end of the 1840s certainly indicated a cone shaped fuze hole with diameters of 1.2 and 1.1 inches on the outside and inside respectively, although the drawings gave no indication of bushing.[57]

Although the introduction of the cylindrical Moorsom fuze in 1851 must have necessitated a change in the size and shape of the fuze hole, according to Majendie, it was not until 1858 that what was known as the "Moorsom gauge" was approved in its final form by the Board of Ordnance.[58] All fuze holes except that of the 32-pounder shell were countersunk so that the shells could be used as hollow shot. All were tapped to 0.2 inch above the bottom of the fuze hole to provide a shoulder to support the bush. In 1867 the dimensions of the fuze holes of naval shells were:[59]

Nature	Diameter Below			Depth		Screw		Bush	
	Countersunk Portion in.	Countersunk Portion Top in.	Countersunk Portion Bottom in.	Countersunk Portion in.	Below Countersunk Portion in.	Depth in.	No. of Threads per in.	Interior Diameter in.	Depth in.
10 in.	1.6	1.45*	1.35	1.85	1.65	1.04	16-1/2	1.23	1.0
8 in. or 68-pdr.	1.6	1.45	1.35	1.85	1.65	1.04	16-1/2	1.23	1.0
32-pdr.	-	1.45	1.35	1.034+		0.85	16-1/2	1.23	0.85

* Before bushing.

+ Not countersunk, but total depth of fuze hole.

Naval shells also differed from common shells in the nature of the bottom or sabot and the manner of its attachment. Originally bottoms were the same for all natures of shell and were attached with metal straps. When double-shotting, that is, firing a shot or shell together, a common practice in the navy, gunners found that the shell was often broken up by the shot. Experiments indicated that if the two projectiles were touching, they survived discharge intact. In 1856 Captain Sir J. Maitland, R.N., suggested that the bottoms of one-quarter of the naval shells supplied be hollowed completely through the centre to expose the shell flush with the lower surface of the bottom; thus the shell would be in contact with the shot if it were fired double-shotted. In 1858 this innovation was extended to all 8-inch and 32-pounder naval shells and in 1859 to the 10-inch shells as well.

Initially these bottoms were strapped on, but in 1859 a new method of attachment was adopted. On each side of the central hole two small inclined holes were drilled that coincided with two similarly inclined holes in the shell. To hold the bottom in place two rivets, which were merely copper pins, were inserted into the inclined holes. They were held in place by inclination rather than by expansion as in the single central rivet method. Since the 10-inch gun was never fired double-shotted, in 1863 the 10-inch bottom was ordered to be made on the land service pattern and to be attached by a single rivet. For the sake of uniformity, however, a few months later it was decided to retain the naval method of attaching the bottom; thus the 10-inch bottoms were manufactured with three holes for either land or sea service shells.[60]

Majendie wrote in 1867 that "... it would be laborious and unprofitable to go into all the different minor changes which have from time to time been effected in the different bursting charges."[61] A survey of the available documentation from about 1750 to the 1860s confirms his opinion, but certain tables of charges recur and certain generalizations can be made, nevertheless.

Until 1864 it was conventional wisdom that shells should not be filled to their capacity. John Muller wrote:

> The quantity of powder they ought to be filled with, so as to burst into most pieces, is not known; but most artillerists agree that they should not be quite full; and Colonel *Desaguliers*, after having made several experiments, imagines, that two thirds of the weight which would fill them is the quantity they should be loaded with.[62]

This rule of two-thirds capacity was being repeated at the end of the eighteenth century.[63]

Before Desaguliers' experiments, John Muller listed quantities of powder which were probably determined in 1742-3.

Nature	Quantity of Powder lb.	oz.
13	9	4.50
10	4	14.75
8	2	3.50
5-1/2	1	1.50
4-2/5	0	8

These quantities were given in a number of manuals or notebooks during the 1760s and 1770s.[64] Although it was not precisely clear, this table probably represents the capacity or near capacity of the shell.

Beginning about 1760, a second table of weights of powder for the bursting charge, which one note book referred to as General Desaguliers' allowance began to appear.

Nature	Quantity of Powder lb.	oz.
13	6	12
10	2	10
8	1	14
5-1/2		12
4-2/5		5

From 1760 until the 1840s these quantities, or amounts varying only slightly, were given for bursting shells.[65] Although differing tables of quantities can be found, it seems likely that the amounts in the first table above, which were equal to or near the shell's capacity, were in use about 1750. Around 1760, following experiments by Desaguliers, those set down in the second table began to be employed. (The practice may be slightly more complicated, since there are indications that shells for sea service mortars (8- and 10-inch) may have contained different amounts of powder during the early period.)

With the development of shells for guns new tables of bursting charges appeared. In 1813 Adye gave the following amounts:[66]

Nature pdr.	Quantity of Powder lb.	oz.
42		14
32		12*
24		11*
18		9
12		5.50

* These amounts were reversed originally.

By the 1840s new guns had been introduced and the quantities seemed to have been increased.[67]

Nature	Quantity of Powder	
	lb.	oz.
12-in.	13	13
10-in.	6	8
8-in.	2	9
42-pdr.	1	8
32-pdr.	1	2
24-pdr.	0	15
18-pdr.	0	12
12-pdr.	0	6

Variations seem to have occurred quite often. Immediately before 1864 the quantities used and the date of their introduction are set out in the following table:[68]

Nature	Common			Naval			Mortar		
	lb.	oz.		lb.	oz.		lb.	oz.	
13-in.							10	8	(20 Aug. '55)
10-in.	6	4	(27 Oct. '62)	6	4	(27 Oct. '62)	5	0	(1 Mar. '59)
8-in.	2	4	(8 Dec. ' 54)	2	4	(8 Dec. '54)	2	4	(8 Dec. '54)
56-pdr.	2	0	(1 Mar. '59)						
42-pdr.	1	6	"						
32-pdr.	1	2	"						
24-pdr.		12	(20 Feb. '58)						
18-pdr.		10	(19 Nov. '59)						
12-pdr.		6	"						

In 1864 the Ordnance finally rejected the view that shells should not be completely filled, and on 22 September ordered that all shells (excepting shrapnel) were to be filled by capacity instead of by weight. On 2 October of the next year a new scale of approximate bursting charges was adopted.[69]

Nature	Common		Naval		Mortar	
	lb.	oz.	lb.	oz.	lb.	oz.
13-in.					10	15
10-in.	6	12	6	5	5	4
8-in. or 68-pdr.	2	9	2	9	2	9
56-pdr.	2	7				
42-pdr.	1	12				
32-pdr.	1	5	1	5		
24-pdr. or 5-1/2-in.	1	0			1	0
18-pdr.	0	12				
12-pdr. or 4-2/5-in.	0	7			0	7

It is perhaps extraordinary that it was not until 1864 that the traditional practice of filling the shell partially was finally rejected. It may have been the influence of the dead hand of an authority as great as Desaguliers, but neither the records of his experiments not his arguments have been discovered. A later authority wrote that a smaller charge produced larger shell fragments; presumably it was felt that they produced greater damage than smaller ones.[70] Whatever the reasons, by 1864 the arguments had been rejected, and four other arguments were advanced in favour of filling shells to capacity (allowing of course sufficient room to insert the fuze):[71]

1) the effect of the shell was increased;
2) the danger of premature explosion was diminished;
3) the shells were less eccentric and consequently more accurate in flight;
4) the issue of bursters was much reduced and simplified.

Before 1860 the bursting charge was issued in a serge bag, but that year it was ordered placed in a pulp or paper bag that was then put inside a calico bag. The calico and paper bags were numbered to correspond to each other, from one to seven, each bag capable of containing a variety of charges.

Bag No.		**lbs.**	**oz.**	**drms.**		**lbs.**	**oz.**	**drms.**
1				24	or under			
2	above			20	to			30
3	"			30	"			70
4	"			70	"		13	
5	"		13		"	2	8	
6	"	2	8		"	4		
7	"	4			"	12		

When the calico bag had been filled, it was marked in black with the word "burster" and the weight of the charge. It was then choked with twine; the choke was not cut off as it had been up to 1859.[72]

Carcass

The carcass was an incendiary device used to set fire to buildings and shipping. During the period studied, there were two carcass forms — oblong and round. Derived from the ancient "fire ball," the carcass was strengthened, either by iron ribs in its oblong form or by an iron casing in its spherical form, to withstand the greater charges of gunpowder. It was filled with an inflammable composition which was ignited by the flash of the service charge, the resulting flames spewing forth from a varying number of vent holes. Depending on its size, a carcass burned from three to 11 minutes and its fire was very difficult to extinguish.[73]

It is not known when the oblong carcass was first introduced or what were the details of its development, but in England it seems likely that it first appeared during the last half of the seventeenth century.[74] It was cetainly in use in the first decade of the next century, for it was described in The Gentleman's Dictionary in 1705:

> A Carcass is an Invention of an oval Form made of ribs of Iron, afterwards filled with a composition of Meal-Powder, Saltpetre, Sulphur, broken Glass, shavings of Horn, Pitch, Turpentine, Tallow and Linseed Oil, and then coated over with a pitched Cloth; it is primed with Meal-Powder and Quick-match, and fired out of a mortar: the Design of it is to set Houses on fire. For lifting it up to put it in the Mortar, it has two small Cords fixed to the sides of it.[75]

A circa 1710 drawing of a carcass, probably by Borgard, showed four ribs contained in a hemispherical bottom and strengthened by a latitudinal iron bar (Fig. 210). Holes were shown at the intersection of the bars which might be interpreted as vents, but they were more likely for rivets. There appeared to be a large central vent where the four ribs intersected from which fire could emanate.[76] These carcasses were probably made for all natures of mortars from the 18-inch (which was probably obsolete by mid-century) to the small 4-2/5-inch Coehorn.

No tables of dimensions have been found for these early carcasses, but in April 1759 the weights of "New Oblong Hammered Iron Carcasses" were established.[77]

Nature in.	Empty lb. oz.	Coated lb. oz.	Filled lb. oz.	Woolded lb.oz.	Primed lb. oz.	Kitted lb. oz.
10	33 0	33 10	68 14	69 8	70 4	71 2
8	15 12	16 1	32 14	33 2	33 10	34 0
5-1/2	1 8	1 10	8 6	8 8	8 9	8 12
4-2/5	1 2	1 4	4 9		4 10	4 12

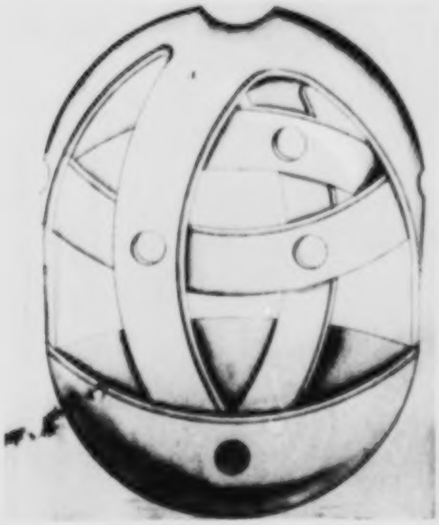


Figure 210. Carcass, circa 1714. (The Royal Artillery Institution, Woolwich, U.K., Borgard, "Practtis of Artillery.")

This table was repeated in various notebooks until about 1800. As well, more detailed measurements also labelled "New Oblong Hammered Carcasses," were copied into two notebooks, one *circa* 1780 and the other *circa* 1800. Interestingly, the dimensions of an 18-inch carcass, which must have been long obsolete, were included.[78]

Although all oblong carcasses were essentially the same, there were minor variations in construction and therefore in treatment between the smaller 5-1/2- and 4-2/5-inch carcasses and their larger brothers. The latter were composed of two iron hemispheres, the top smaller than the bottom, joined together by four iron ribs, which were strengthened by a transverse iron bar. Two ears or lugs were attached to the upper hemisphere by which the carcass was lifted. The 5-1/2- and 4-2/5-inch carcass lacked the top and lugs.[79]

By 1780 what may be regarded as the classic method of preparing oblong carcasses had been developed. Before then information is slight, but there are some indications of the earlier, cruder techniques. A definition in Chambers' *Cyclopaedia* of 1751 seemed to suggest that a canvas bag was filled with composition and then placed inside the iron framework:

> Carcasse, or Carcass, a kind of bomb, usually oblong, or oval, rarely circular; consisting of a shell, or case, sometimes of iron, with holes; but more commonly of a coarse strong canvas, pitched over, and girt with iron hoops; filled with combustible matter.[80]

A note on carcasses in Smith's *An Universal Military Dictionary*, although somewhat confusing, suggested a similar arrangement.[81] On the other hand, in his notebook of 1766, Adye wrote:

> They [carcasses] are cover'd over with a coarse piece of Canvas and filled with ... composition...
>
> The Carcass being put into the Bag of coarse Canvas which is called Coating it...

An accompanying diagram showed the carcass sewn into its canvas bag.[82] By 1780 carcasses were prepared in a more sophisticated manner.

During the eighteenth century various combinations and proportions of materials were used in the preparation of the inflammable composition with which carcasses were filled. In his notebook, *circa* 1750, Glegg listed six different mixtures and later sources indicated others.[83] The basic ingredients were gunpowder (usually corned but sometimes mealed) and pitch, with saltpetre, sulphur, turpentine, and tallow, all or severally mixed in. One of these mixtures was recorded consistently from 1760 until 1801, when Adye referred to it as the "Old Carcass Composition":[84]

	lb.
corned powder	30
swedish pitch	12
saltpetre	6
tallow	3

This may be regarded as the standard formula for carcass composition during the last half of the eighteenth century.

The corned powder was spread on a table and any lumps in it were crushed with a rubber. The saltpetre was evenly poured over it through a fine hair sieve, and the two ingredients were well mixed by hand. The pitch and tallow were melted in an iron pot over a fire and stirred until they were thoroughly mixed and quite hot. Then the mixture was transferred into a copper pot that was resting in a copper vessel full of hot water. The powder and saltpetre were added gradually and the mixture was well stirred until all the ingredients were completely combined.

In preparation for being filled with the composition, the carcasses were coated with sacking. In the case of the large carcasses, the open spaces between the top and bottom hemispheres were covered with a layer of sacking, sewn on with pack thread as tightly as possible at the top and bottom of each bar. One quarter was left open for filling. In the case of 5-1/2- and 4-2/5-inch carcasses, the sacking was sewn on over all four quarters, but the top, where the upper hemisphere was missing, was left open for filling.

Since the composition was put into the carcass by hand, the workman responsible greased his hands well with tallow to prevent the mixture's adhering to them. When the composition had cooled sufficiently, he filled the carcass through the space left open. Then five plugs of well-greased wood, 5 or 6 inches long and 3/4 inch in diameter were inserted into the mixture through the vent holes in the upper hemisphere. The composition was allowed to cool for an hour or more, during which time the composition settled. More composition was put in to make up for whatever was lacking, and the sacking was then sewn up as tightly as possible. While the composition continued to cool and harden, the workman rolled the carcass about to prevent it from swelling out one side more than another. (The precise manner of plugging the smaller carcasses was not well described, other than that they were plugged (but with only four plugs) in the same manner as the larger. This was obviously an oversimplification.)

While the composition was still hot, four holes were cut in the sacking, one in each quarter, alternately 2 inches from the top and 2 inches from the bottom. Loaded and primed pistol barrels, presumably as booby traps, were inserted into the carcass through these holes flush with the sacking. Pistol barrels were not placed in the 5-1/2- and 4-2/5-inch carcasses.

When the composition had cooled and hardened, the carcass was woolded, that is, line was wound around it where the hemispheres met the sacking. For the 10-inch carcass, the line was 5/8 inch in diameter at the top and 3/8 inch at the bottom, and the woolding was about 2 inches wide. For the 8-inch carcass, the line was 3/8 inch diameter at the top and 1/4 inch at the bottom, and the woolding was about 1-1/2 inches wide. The dimensions of the line for the 13-inch carcass have not been found. It is not clear that the small carcasses were woolded, but it would seem reasonable to do so where the sacking met the bottom hemishpere.

Next, the greased plugs were removed and the holes cleared out in preparation for priming with fuze composition. Each ladle-full of 4 drams that was placed in the holes was driven 12 strokes with a drift and mallet. When each hole was half full, cotton quick match was inserted: in the top hole of the large carcasses it was inserted double with two ends protruding; in the side holes and in those of the small carcasses it was put in single. The dimensions of the match was:

Nature of Carcass in.	Threads no.	Length Top hole in.	Length Side holes in.
10	4	12	9
8	3	9	6
5-1/2	2		4
4-2/5	2		4

The match was set with mallet and drift, and then the vent hole was driven with fuze composition as before until within an inch of the top. The priming was finished by putting in a ladle-full of mealed powder, driving it, and then by coiling the ends of the match into the hole. Each hole was plugged with a piece of paper to protect the match and composition from the kit which was to be applied next.

Kit was made of rosin, pitch, beeswax, and tallow, melted together in a pot and made very hot. It was brushed on the top of the carcass and a circular cap of sacking or barras (with slits if necessary cut for the ears or lugs) was stuck on. Then the whole carcass was brushed over with kit, and sawdust was sprinkled over it to reduce the kit's stickiness.[85]

The oblong carcass was ballistically inefficient, or, in John Muller's words, "... the flight of the oblong is so uncertain...," but so long as the range was short and the target large this uncertainty was probably not a great problem.[86] A noteworthy and effective use of oblong carcasses was at Quebec in August 1759. George Reed gave this account of the bombardment from Pointe-Lévis:

> Being orderd to destroy the lower Town by fire, if possible, several expedients were tried without effect; the distance being so great, that a 10-inch Sea Service Mortar loaded with 5 lbs. of powder, could not throw a 10 inch oblong Carcass over the river St. Lawrence; and when 6 lbs. were tried, the Carcasses were blown to pieces.
>
> After a number of fruitless trials, I fell upon the following vizt. — over 6 lbs. of powder, I rammed a wad of grass or half made Hay, which filled the Chamber of the said mortar so that the Carcass rested upon the Wad; and then ten out of twelve, were thrown into the middle of the lower town; and set it on fire so effectually, that before morning the greatest part of it was destroyed.
>
> Some time after, I was ordered to try if the upper Town could be destroyed by Oblong Carcasses from the same Mortar; In which I likewise succeeded with 7 lbs. of powder (with a wad over it as beforementioned) which threw seven carcasses (out of ten) into the upper Town, and set it on fire also, and caused a great conflagration — In both Towns, there were 503 Houses and one Church destroyed.[87]

Reed's account of the bombardment of Quebec highlighted problems of the oblong carcass's range and strength, and by about 1780, according to contemporary writers, it had been replaced by a round, shell-like carcass.[88] Its demise seems to have been exaggerated for dimensions of oblong carcasses continued to be printed into the first decades of the nineteenth century.[89] Of more significance was their inclusion in ammunition lists in Canada during the Napoleonic wars.[90] In all likelihood they were finally retired sometime after 1815; writers in the last half of the 1820s were quite definite that they were no longer in use.[91]

The definition of a carcass in Chambers' Cyclopaedia of 1751 — "a kind of bomb, usually oblong, or oval, rarely circular..." — implied that spherical carcasses, although exceptional, had been devised by mid-century, but it was not until 2 August 1760 that the dimensions of round carcasses were officially established.[92] The evidence suggests that initially only a 13-inch round carcass was developed, although George Smith, in his An Universal Military Dictionary, printed the results of trials, probably in the 1770s, of round 8- and 10-inch carcasses.[93] At first, the 13-inch round carcasses were made with either five, four or three vent holes, but by about 1780 only the variety with four holes was in use.[94] Presumably the selection of four holes was made as a compromise between the most efficacious transmission of fire and the least weakening of the shell casing.

Although the evidence is not conclusive, the round 13-inch carcass may have been first developed for sea service, to be fired from bomb ketches. Smith wrote: "There are other than oblong carcasses for the sea service, which differ from a shell only in the composition, and the 4 holes from which it burns when fired."[95]

Mountaine, in The Practical Sea-Gunner's Companion, after describing large oblong carcasses, went on:

> The next invented were cast Spherical Carcasses, in Diameter 12-3/4 Inch, with five Holes; afterwards their Number was diminished to three; but all these are now obsolete, chiefly, I believe, because they discharged their Combustibles too precipitately; for those now in Use are of the same Nature and Magnitude with the last mentioned, but with one Hole only, as the Shells have, but much larger, that the Composition may be discharged with a visible Flow; for by the Assistance of these in a dark Night, they are able to direct the Mortars for execution.[96]

His remarks about the number of vents was at variance with other sources, but in a manual exclusively devoted to naval gunnery, it was suggested that the 13-inch round carcass was first developed for sea service.

There is clear evidence of the adoption of 13-inch and at least experiments with 8- and 10-inch round carcasses by 1780. But the development of a complete range of these carcasses, which could be fired from guns and carronades, as well as from mortars and howitzers, seems to have been contemporaneous with the development of shells for the same weapons. After all, a round carcass was merely a shell filled with a flammable composition instead of a bursting charge, with a number of vents out of which flame issued. It is significant, then, that the first table of dimensions for all natures of carcasses that has been found was dated 1796, in the same decade that a complete range of shells was developed.[97]

For the next 60 to 70 years round carcasses were part of the arsenal of the Royal Artillery. During that time there were only minor changes made in their design, but because the tables consulted gave only weights, not precise measurements, it is impossible to detail what changes were made. Despite this shortcoming, a comparison of these tables indicates perhaps three sets of specifications. Until 1826, no set of dimensions other than the 1796 table, which was published in Adye's Pocket Gunner, has been discovered.[98] It is not unreasonable to assume that there were no changes made to carcass design until after the end of the Napoleonic wars and possibly until the early 1820s, when we know that there were changes in shell specifications.

From 1826 until 1853, a series of tables appeared in a number of manuals and note-books which, with some minor exceptions, were in agreement.[99] Only the exterior diameters and the weights were given, but it seems likely that few if any, and then only minor, changes were made to carcasses during this period. Toward the end of the 1850s, a third set of dimensions appeared, which continued to be published, with minor variations, throughout the 1860s.[100] In 1860, the Royal Laboratory published a scaled drawing and dimensions to govern the manufacture of carcasses in the British service.[101]

In his authoritative and comprehensive study of ammunition for smooth-bore ordnance, Majendie suggested that the adoption of four vent holes took place about 1808.[102] He based his conclusion on a note appearing in a report of experiments with carcasses carried on since 1855, but according to sources from the 1760s and 1770s, carcasses with four holes were preferred long before (see above). Adye's Pocket Gunner, which published the table of dimensions from 1796, did not indicate the number of holes. Later sources were in conflict. In his notebook in 1825, Mould clearly stated that there were three vent holes; in 1826 Swanston and in 1828 Spearman just as clearly wrote that there were four. In 1847, Griffiths described carcasses with three or four holes, and in 1853, the Aide-Mémoire referred to 3 and 4 holes.[103] Other sources said that the carcass was pierced with three vent holes.[104]

Since no new carcasses were manufactured during the peace between the Napoleonic and Crimean wars, it seems likely that both patterns of carcass were kept in storage ready for use. During the Crimean war, it was found that the carcasses with four vents tended to break up on discharge. Experiments carried out in 1855 led to the adoption of three vents. Finally in 1860 drawings and patterns were approved to govern the future manufacture of carcasses (Fig. 211).[105]

At the same time that a complete range of round carcasses was designed, a new inflammable composition also appeared, possibly for use in the round carcasses.

	lb.	oz.
saltpetre	5	
sulphur	2	
antimony		8
rosin	1	
tallow		8

Henceforth gunpowder would no longer be included but rather two of its components, saltpetre and sulphur, along with tallow and the new substances, antimony and rosin. Pitch made a brief reappearance in 1813,[106] but in 1825, Mould set down the ingredients and their proportions which remained standard into the 1860s:[107]

	lb.	oz.
saltpetre	6	4
sulphur	2	8
rosin	1	14
antimony		10
turpentine		10
tallow		10

The manner of preparation of the composition and of the filling of a round carcass was similar to that of an oblong carcass. The dry ingredients were sieved and mixed thoroughly together, either by hand or with a copper slice. The tallow and turpentine (some sources say the rosin, as well) were melted in an iron pot set in a boiler containing hot oil. The dry ingredients were added gradually and the mixture was stirred for about 20 minutes until it became a thick paste. Then it was ladled out of the pot onto a board where it was allowed to cool sufficiently that it could be handled.

The workman who was to fill the carcass greased his hands well in order to prevent the composition sticking to them. Then he rolled the composition into small pieces, and having closed all but one of the vent holes with corks, proceeded to fill the carcass through the open hole, ramming the pieces of composition home with a mallet and drift. When the carcass was completely filled, the corks were removed and well greased wooden plugs were thrust through the vent holes into the composition. Initially, these plugs seem to have been all the same length, depending on the nature of the carcass, but by the 1860s one plug, which penetrated more than halfway through the composition, was longer than the other two. These shorter plugs approached the longer near the centre of the composition, but did not quite touch it. All three were tied together to prevent their moving while the composition hardened. When it had hardened, the plugs wer removed, and the holes remaining were driven with fuze composition, matched, and primed like fuzes. Then the holes were plugged with brown paper and covered over with circles of kitted canvas or barras cut larger than the diameter of the holes. Finally the circles were covered with sawdust to reduce the stickiness of the kit.[108]

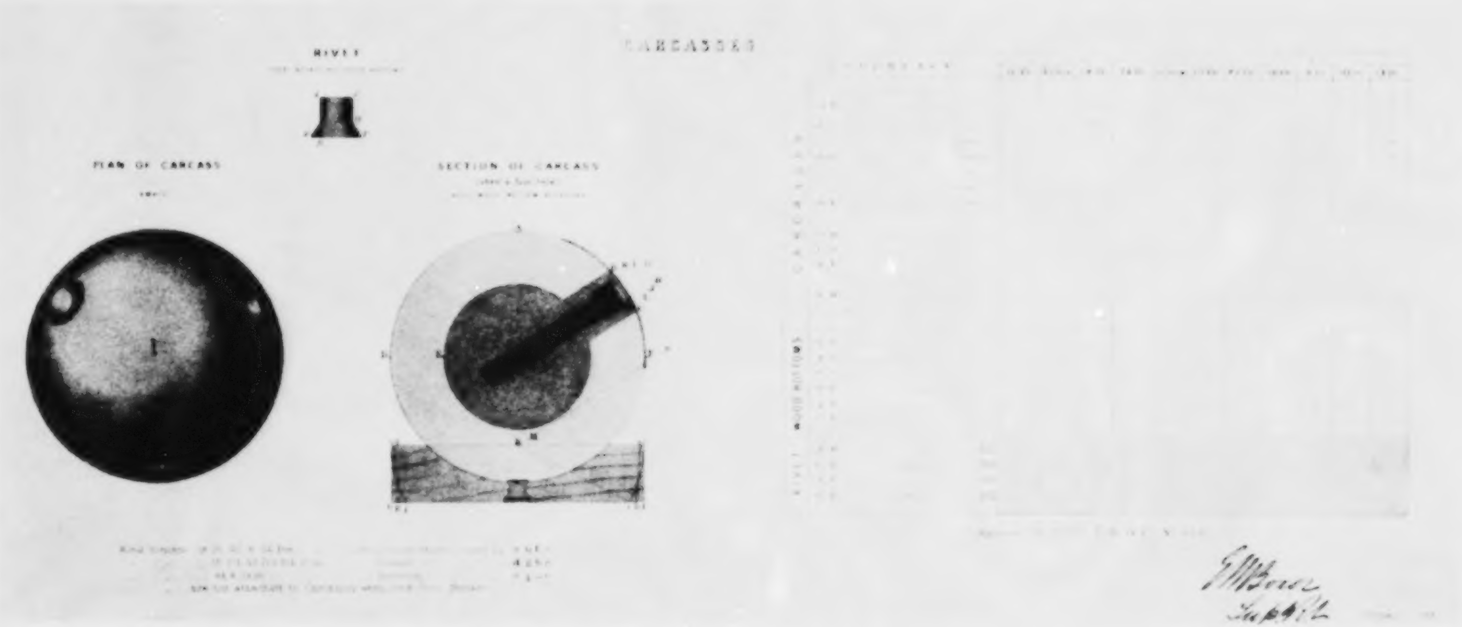

CARCASSES
RIVET
PLAN OF CARCASS
SECTION OF CARCASS

Figure 211. Carcasses. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate 20, February 1868.)

Grapeshot

Early in the history of artillery, gunners had found that firing a shower of small projectiles at short range against men massed together could be very destructive. Initially they may have used whatever odds and ends were at hand – stones, balls, nuts, bolts, – rammed in on the powder and fired off, but in time they began to put the projectiles into bags or metal containers, calling it langridge, a term of unknown origin. Grapeshot, like case or canister shot, was a sophisticated version of this primitive weapon.[109]

Grapeshot consisted of a flat circular bottom with a spindle extending from its centre, both made of either iron or wood, the spindle surrounded by cast iron balls, usually nine; the whole was enclosed in a canvas sack, and the balls were held in place by a "quilting" line looped and tightened round them. Its name derived from its supposed resemblance to a hanging bunch of grapes. When it was fired from a gun, the bag burned or burst releasing the balls over a broad front. It was used mainly in the navy or from fortifications; it was not fired from brass field pieces because it damaged the bore and could quickly render the gun unserviceable. Contemporaries mention its use from field guns, but probably either the term grape included what later was called canister or case shot, or the writers were using language imprecisely.[110]

Until about 1800 there was a distinction between land and sea service grapeshot. The former was made up of a wooden bottom and spindle with various numbers of balls quilted into the canvas sack, the quantity depending on the calibre of the gun; the latter was composed of an iron bottom and spindle around which nine balls were quilted regardless of calibre. It is not known precisely when the land service grapeshot was declared obsolete, but by 1801 Adye, in his Pocket Gunner, indicated that there was only one sort for both land and sea service.[111]

Two tables of specifications for land service grapeshot have been prepared, the first drawn up by Albert Borgard in 1717, the second, contained in an untitled bound manuscript notebook *circa* 1750 attributed to Samuel Glegg, an officer of the Royal Artillery. While not entirely in agreement, both tables are very similar and are clearly describing the same sort of grapeshot. In addition, Glegg outlined a system of determining dimensions and gave a sketch of the spindle and bottom. Borgard also drew up a table listing the materials needed to make up grapeshot.[112]

For each calibre of gun from the 42- to the 6-pounder there were usually five sorts of grapeshot; for the lesser calibres only one kind, except for the 3-pounders and the 8-inch howitzer for which there were two.[113]This variation was occasioned by the size and number of balls used – the smaller the ball, the larger the number necessary to make up the grapeshot. For example, the following table shows the details of weight and arrangement of the balls for grapeshot for a 42-pounder.

Weight of ball lb.	oz.	Diameter ball in.	No. of balls per row	No. of rows	Total No. of balls
1	8	2.201	6	4	24
1	0	1.923	7	5	35
	13-1/8	1.800	8	6	48
	8	1.526	10	7	70
	4	1.211	14	11	154

Obviously, as the calibre of gun lessened, the weight of the balls also decreased; for example, the weights of the balls for the five grapeshots for a 9-pounder were 6-3/4, 4, 3, 2, and 1-1/2 ounces.

The spindle or pin comprised a relatively thick barrel surmounted by a thin neck and then a thicker head; a thin tennon projected from the bottom of the barrel. the canvas sack was sewn into a hollow cylinder, somewhat less in diameter than that of the bottom, turned inside out, and tied round where the tennon joined the barrel. It was then reversed up over the spindle, filled regularly with shot, and when full, tied at the neck and quilted. The quilted grapeshot was then fitted to the bottom, which was hollowed out to receive the bag of shot and was pierced with a hole at its centre to take the tennon of the spindle. The excess length of the spindle was cut off, and it was wedged securely into place. Finally, the grapeshot was painted red.[114]

John Muller's Treatise on Artillery and George Smith's An Universal Military Dictionary confirmed generally the previous description of land service grapeshot in the third quarter of the eighteenth century. But while the spindle and bottom were wooden and balls of various sizes and weights were used, both writers indicated that the bottom, which was probably no longer hollowed out, was enclosed within the sack before the shot was put in and quilted in place.[115] Both writers indicated some dissatisfaction with the projectile, and an artillery officer, George Williamson, writing about 1770, criticized quilted grapeshot generally and the size of the wooden pin in particular:

> ... for experience the wisest & best of Masters, has taught us how much the wooden pin has scattered the shott [sic] in the canvass sic bag quilted grape; particularly when the Pin is thick as some have been extravagantly so without any reason given to us as yet why they should be so.[116]

It is possible, then, that by the end of the 1770s the bottom and spindle, while still made of wood, had been modified in size and shape.

This land service grapeshot may have become obsolete by the 1780s; there is no record of it later than the reference to it in Muller's 1780 edition of his Treatise on Artillery. Rather a variety designated "New Pattern Grape Shot" appeared probably in the 1780s. Its spindle and bottom were made of iron, and they, along with the canvas bag, were identical to those for sea service grapeshot; unlike the latter, however, it was made up of 20, rather than nine balls.[117] Because of this one other modification was necessary: "... as the shot are much smaller than those with 9 shot, it is necessary to wrap hemp, rubbish or tow tight about the spindle in order to bring out the shot equal to the diameter of the Bottom of the Tampinion [sic]."[118] Possibly in the land service the wooden bottom and spindle have been discarded in favour of the iron bottom and spindle of the sea service, but a large number of balls, 20, were retained. By 1800 even this pattern seems to have been found inadequate, and sea service grapeshot was adopted for both services.[119]

Sea service grapeshot remained essentially unchanged for about a century. Invariably it was composed of nine cast iron balls, of various sizes depending on the calibre, grouped in three tiers around a cast iron spindle which was fixed securely to a cast iron bottom; until about 1800 the whole was enclosed in a canvas bag, thereafter only the shot and spindle, and quilted to hold the balls securely in place. The earliest detailed references found to sea service grapeshot occurred in Glegg's notebook, circa 1750. There were two tables of dimensions, one slightly different from the other, but the differences were so small that practically they would make little difference.[120] One of these tables was repeated, more or less, in various notebooks until this pattern of grapeshot became obsolete after 1856.[121]

Some minor changes did occur. About 1800 the patten of the canvas bag was altered so that it was slightly smaller at the top. At the same time a new method of quilting was adopted in which the bag no longer enclosed the whole of the projectile but only the balls and the spindle.[122] Much later, in the 1840s, for reasons that are unclear, minor changes were made in the diameter of the spindles — those for 42- and 32-pound shot increasing slightly and those for 24- to 6-pound shot decreasing slightly.[123]

The introduction of new guns in the 1830s and 1840s necessitated new calibres of quilted grapeshot for the 56- and 68-pounder guns and for the 8- and 10-inch shell guns. Grapeshot for the 10-inch gun was composed of 24 3-lb. balls, for the 68-pounder and 8-inch gun, 15 3-lb. balls, and for the 56-pounder, 12 4-lb. balls, put together in the usual manner.[124]

On 2 September 1822 the Board of Ordnance approved a new pattern of grapeshot designed by William Caffin of the Royal Laboratory, Woolwich.[125] Caffin's or tier grapeshot consisted of nine cast iron balls arranged in three layers between four iron plates, held firmly in place by a central wrought iron spindle and nut. Later, 56- and 68-pounder grapeshot had four and five balls respectively in each of the three tiers. The lower plate, which was made of wrought iron, was stamped with indentations sufficient in number for the shot of the first layer to rest in. The other plates, made of cast iron, were manufactured with holes equal to twice the number of shot in a tier in order to receive the shot immediately above and below. (For convenience in manufacture and ease in assembly the top plate was cast with the

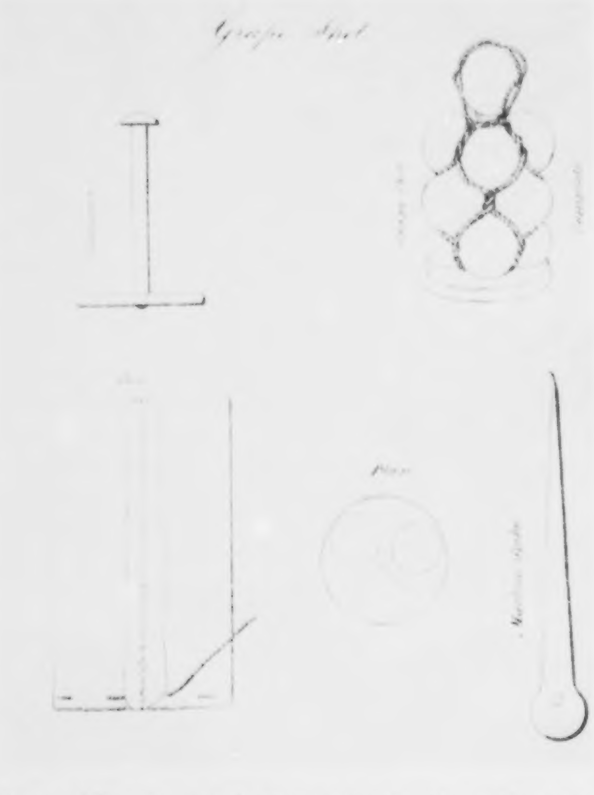


Figure 212. Grapeshot. (The Royal Artillery Institution, Woolwich, U.K., "Artillery Implements...")

same number of holes as the other two, although only half that number would be necessary.) When assembled, the grapeshot was painted black.[126]

Caffin's grapeshot had a number of advantages over the quilted pattern. It was much less perishable; the rope and canvas of the older variety often rotted, thus rendering the projectile unserviceable. As well, since the components of the new pattern were interchangeable, if the grapeshot did become damaged, a number of the damaged projectiles could be combined to obtain serviceable weapons. Caffin's pattern could be easily assembled by unskilled labour, even on station, while manufacturing quilted grapeshot was not only tedious but required considerable training and skill. The destructive potential of the new pattern was probably greater, although Sir Howard Douglas expressed some reservations in 1840.[127]

According to Majendie in his authoritative work on smooth-bore ammunition, although the Board of Ordnance approved Caffin's grapeshot in 1822, it was not manufactured until 1856.[128] Majendie did not explain this strangely large gap of 34 years between approval and manufacture. His statement appears even more unusual in light of numerous references to, and dimensions of, Caffin's grapeshot given in notebooks and manuals compiled during the intervening years. These also raise questions since one group of references gave the weight of shot for the equivalent calibre of quilted grapeshot[129] while the other group listed shot that was consistently lighter.[130] It is difficult to explain these different sets of specifications; perhaps one was in error, or perhaps there were two patterns of Caffin's grapeshot, and a final decision was not made until 1856. Even after 1856 there were variations in the tables given by various authorities, but the dimensions given by Majendie and Lefroy were probably the most accurate.[131]

Nature of Ordnance	Shot							Plates		Tampion*		Case		Total Weight	
	Weight of each Lb.	Oz.	Number in a tiers	Number of tiers	Total Number	Number of Wrought Iron	Number of Cast Iron	Diameter Inches	Thickness Inches	Length Inches	Thickness Inches	Depth Inches	Diameter Inches	Lb.	Oz.
10 inch	3		8	3	24	2	-	9.592	.165	-	-	8.1	9.82	81	7
8" or 68 pds.	3		5	3	15	1	3	7.82	.5063	10.375	.75			65	9
56 pds.	4		4	3	12	1	3	7.45	.5063	11.25	.75			69	7
42	4		3	3	9	1	3	6.735	.5	10.5	.5			48	11
32	3		3	3	9	1	3	6.147	.5	9.37	.5			36	12
24	2		3	3	9	1	1	5.57	.375	8.375	.5			25	3
18	1	8		3	3	9	1	3	5.074	.3125	7.375	.5		18	13
12	1		3	3	9	1	3	4.402	.3125	6.375	.375			12	15
9		13 1/8	3	3	9	1	3	4.06	.25	6.127	.3125			10	12
6		8	3	3	9	1	3	3.532	.165	5.25	.3125			6	11
3		4	3	3	9	1	-	2.71	.165	-	-	3.25	2.808	2	11

* spindle

Note: the grapeshot for a 10-inch gun was packed in an iron cylinder (sheet iron, No. 16 wire gauge), with plate iron end and top (sheet iron, No. 8 wire gauge), with an iron handle; for the 3-pounder gun it was packed in a tin cylinder with a tin end, plate iron top, and rope handle. Both were painted red.[132] The 3-pounder grapeshot was abolished 5 June 1866.[133]

If Caffin's grapeshot was first manufactured in 1856, it had a short life. It was declared obsolete for the naval service on 28 February 1866, and its manufacture for the land service was discontinued after 20 September 1866, although it was still to be issued until the stores of it were exhausted.[134]

A grapeshot designed specifically for carronades, which might better have been termed heavy case, was first described in a manual of 1840 and continued to be included in lists of ammunition into the 1860s.[135] Each calibre was composed of the weight and number of balls of the equivalent calibre of quilted or Caffin's grapeshot, but they were packed in tin cases, similar to but longer than those used for cannister or case shot. Throughout the 1840s and '50s it was said that its bottom was closed with a wooden tampeon, possibly for attaching a cartridge, but by 1867, according to Majendie, the tampeon had been replaced by a tin end. Its top was a piece of plate-iron, equipped with either an iron or a rope handle.[136] Since the weight and numbers of the balls remained constant, changes in the design of the case were perhaps reflected in changes in the total weight of the grapeshot; it increased in weight generally from the 1840s to the 50s. By 1867, according to Majendie, it was generally lighter. This grapeshot was painted red.

Case or Canister Shot

Fired from most pieces of artillery except mortars, case or canister shot consisted of a tin cylinder, whose diameter varied according to the calibre of the piece, filled with iron balls, called sand shot, whose size and number also varied with the calibre. One end was closed with a tin plate and the other, until the 1860s, with a wooden bottom which rested against the cartridge. Case for field service was often fixed to the cartridge to facilitate quick loading. When fired, the tin cylinder held the balls together as it passed down the bore and then burst at the muzzle releasing them in a rapidly expanding cone. Because of the size of the cone and of the rapid loss of force of the small balls, case was rarely used beyond 300 yards. At short range it was effective against troops in close formation and especially against massed cavalry.[137]

Like grapeshot, case shot was a descendant of the cruder langridge. Its early history is obscure, but it was said to have been used at the siege of Constantinople in 1453. Something similar, called hail shot, appeared in Germany in the next century.[138] In England, "Cases filled with square shott" were first recorded in an inventory of stores at the Tower of London in 1603; "Tyn cases fill'd with Musquett Shott" were included in 1635 and in subsequent inventories up to 1725/6.[139] There may have been some confusion of case and grapeshot, or an imprecision in terminology, for in a document of 1755 the hybrid "Tin Case Grape shot" was used, and a description written in 1766 suggested that case shot developed subsequently to grape.

> Case Shot signifies a Tin Case, made to fit y^{e} Bore of the different Guns & filled full of small shot. Formerly the Method was to quilt these small shot on a wooden bottom around an Iron Spindle, which was call'd Grape Shot, but latterly the present Method of putting them into a Tin Case has been found less troublesome and expensive.[140]

An earlier variation, referred to as late as the 1770s, was called "Matted Shot." Iron balls were held in place on a wooden bottom by a congealed mass of tallow and tar, presumably cylindrically shaped to correspond to the calibre of the piece. It was composed of shot heavier than those for case and was perhaps more similar to true grape.[141] It is not known how extensively it was used.

Although the table of matted shot gave the quantities of materials to make shot for all calibres from 42- to 3-pounders, the table of 1755 gave details (and then incompletely) of case shot only for 12-, 6-, 3- and 1-1/2-pounders, which were undoubtedly field guns. Possibly only field case was being manufactured, but more likely the table had not been completed.[142] Three years later case for 24-pounders, as well as for 12-pounders, was shipped out for the siege of Louisbourg, and by 1766 dimensions of it for all calibres from 42- to 1-1/2-pounders and for the three howitzers (8-inch, 5-1/2 inch, and 4-2/5 inch) had been set down. Either two or three kinds of case were listed for each calibre from the 24- to the 9-pounder inclusive (only one sort for each of the other calibres), the difference between them being in the size of and therefore the number of balls in the tin cylinder.[143] Virtually these same dimensions were reproduced in a notebook of artillery experiments, circa 1770, with the added notation that certain of the case shot were "... thought most proper for the land service." For those calibres with more than one kind, that with the heaviest shot was indicated, except for the 24-pounder where all three sorts were chosen and for the 5-1/2-inch howitzer where that with the lighter shot was selected.[144]

Although one authority has written that case shot was first used on ships of war in 1760, the earliest distinct reference to sea service case that I found appeared in Smith's An Universal Military Dictionary of 1779 where dimensions were specified for it over the whole range of calibres. It was similar to land service case, but the individual balls contained in the tin cylinder were consistently heavier for each calibre of sea service case although, with the exception of the 42-pounder which was 3-1/4 pounds heavier, the total weight of each round was about the same. The tin cylinders for land and sea service seem to have been interchangeable.[145] The wood bottoms may also have been the same for both services, but later sources were quite clear that sea service bottoms, since sea service case was not fixed to the cartridge, were different.

By the 1790s, perhaps before, a complete range of case shot had been developed - for land service, sea service, carronades, howitzers, and even mortars. How successful firing case from mortars was is questionable; nevertheless, tables of dimensions are extant. In essence, there was no change in design — a tin cylinder sealed at one end with a tin plate, filled with iron shot, and stopped at the other end with a wooden bottom, nailed or bradded into place. The bottoms varied in size and shape according to the service and the nature of the ordnance. Those for the land service were relatively long (but shorter than they had been in the 1770s); the section that protruded from the canister and over which the cartridge was fitted for field service was circled with two parallel grooves for tying on or choking the cartridge. Since sea service case was never fixed to the cartridge, its bottom was much shorter, lacking the grooved projection to which to attach the powder charge. Carronade case bottoms were similar. Those for howitzers and mortars were hemispherical in order to fit the chamber of the artillery piece.[146]

An innovation of the 1790s was the design of what was called tier case shot for the 12-, 6-, and 3-pounder field guns. Its name derived from the manner in which the balls were placed in the cylinder — one by one in layers or tiers rather than being poured in promiscuously. For the heavy and medium guns of each calibre there was a large and small case shot of 15 and 41 balls respectively (heavy case); for the light guns similar kinds of 12 and 34 balls respectively (light case). The balls of the heavy case were laid in five or six tiers, those of the light in four or five tiers. Since it held more balls, the length of the tin cylinder for heavy case was longer than that for light or common case. The size of the large balls for each calibre whether heavy or light was the same, as were the small balls. But they were considerably larger and heavier than those of common case, the large ones being comparable to grapeshot, and even the light guns were firing a weight of metal slightly in excess of their nominal poundage.[147]

The patterns of case shot developed in the 1790s probably remained unchanged until the 1820s. Then, sometime before 1826, Millar introduced some modifications (except for carronade case which remained unchanged).

> The weights and dimensions of the cases ... apply to the new pattern case shot introduced into the service by Major General

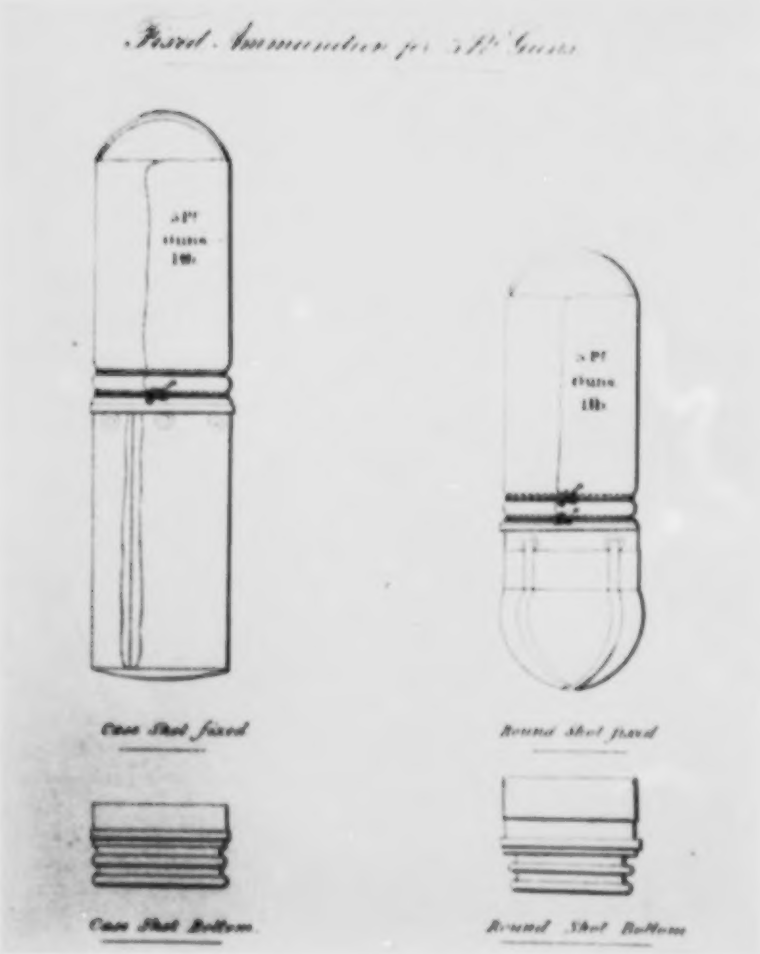


Figure 213. Fixed Ammunition for 3-pounder Guns. (The Royal Artillery Institution, Woolwich, U.K., "Artillery Implements...")

> Miller [sic]. The depth of the old pattern cases is generally four or five tenths of an inch less than the New.[148]

Although the weight of the individual ball for each calibre remained the same as before, the number contained in each canister generally increased; thus, probably, the need to increase slightly the length of the case.

Tier shot for field guns also changed; the heavy case of 15 balls and the light case of 12 and 34 balls vanished by 1826. The case of 41 balls remained for all calibres but new patterns of 126 for the 12- and 9-pounders and of 85 balls for the 6-pounders (but not for the 3-pounder) were recorded.[149] According to Brigadier O.F.G. Hogg, the light case was abolished on 25 November 1830, although it was still recognized in manuals in the 1840s.[150]

While case shot for mortars vanished by the 1820s, probably because of its ineffectiveness, that for howitzers was modified and two new patterns were developed for the new 24- and 12-pounder Millar brass howitzers. Excepting those for the case of the 8-inch howitzer, the weight of each ball was established at 2 ounces, and in consequence the number of shot increased. (There is evidence in a table in a 1825 notebook of a heavy case shot for the 5-1/2-inch brass howitzer containing 20 balls each weighing 13 ounces, but it seems to have been short-lived.[151]) As well, the case shot for the 10-inch howitzer, which had not been listed earlier, was made up of 170 balls of 8 ounces each. The new 24- and 12-pounder Millar howitzers did not fire the case shot of the 5-1/2- and 4-2/5-inch howitzers, to which they were equivalent in calibre, but a heavier case of 140 and 84 balls respectively.[152]

Although Majendie, writing in 1867, claimed that all case shot before 1861 had wooden bottoms, both Swanston in 1826 and Spearman in 1828 included dimensions for iron bottoms or tampeons as well as those for wooden.[153] It may be that iron bottoms were not officially sanctioned, but Fitzhugh wrote in his notebook in 1845:

> Some case shot have iron bottoms as they take up less room in a limber. The end of the case is then cut down a little way in strips and turned over the iron bottom.[154]

This remark appears to have applied to the field service. Also writing in the 1840s, Straith noted that a canister could have either a wooden or an iron bottom, but he argued that iron bore the explosion of discharge better and kept the balls together longer, thus increasing range and effectiveness. The objection that the iron bottom damaged the bore of brass pieces was exaggerated, some felt, and was more than made up for by superior range.[155] As early as the late 1820s, then, perhaps some iron bottoms were being used.

By the 1840s only minor changes had been made in case shot. It was introduced for the new 10- and 8-inch guns; the 10-inch case held two sizes of balls, 34 of 1 pound and 50 of 13-1/8 ounces, while the 8-inch contained 90 balls each weighing 8 ounces. Case for the 68-pounder was the same as for the 8-inch gun. The bottoms were probably iron rather than wood. Otherwise, the number of balls in 4- and 3-pounder commmon case was increased from 28 to 32 and from 34 to 41 respectively. Although Griffith continued to include light case for the field service in his manual, probably it had ceased to be used and only the case holding 41 balls was in service.[156] Rather puzzlingly, the dimensions of the cases and of the bottoms changed, the cases becoming shorter and the bottoms thicker.

The tables of dimensions from the 1840s showed three kinds of case for howitzers. First there was the case for common howitzers, presumably the old and largely obsolete 8-, 10-, 5-1/2-, and 4-2/5-inch brass howitzers. Then, there was the case for the Millar howitzers, the iron 10- and 8-inch and the brass 24- and 12-pounder pieces. This was of two kinds, one having a conical wooden bottom and the other an iron plate. The weight and the number of balls in the 10- and 8-inch and the 24-pounder were the same for either pattern, but the case was shorter if an iron plate bottom was used. The 12-pounder case with an iron bottom held more shot, and consequently the case was longer than that with the wooden bottom.[157]

Few changes occurred over the next decade. Case shot for the brass 32-pounder howitzer, which came into service in the early 1840s, and for the sea service brass 24- and 12-pounder howitzers appeared in the ammunition lists. The 32-pounder case contained 105 balls each weighing 3-1/4 ounces. The sea service weapons fired much heavier balls — the 24-pounder 30 balls of 8 ounces and the 12-pounder a mixture of 15 balls of 8 ounces and three balls of 4 ounces. Other than some minor revisions in the number of balls is some calibres, the only major change was the reduction from 140 to 100 balls in the 24-pounder howitzer case shot, which made it the same as that for the brass 5-1/2-inch howitzer.[158]

Major revisions were made to the patterns of certain case shot in the 1860s.

Because of the difficulty of securing seasoned wood for bottoms, on 26 May 1859 Boxer proposed the substitution of sheet iron or tin plate. On 27 March 1861 sheet iron was approved for the bottoms of all case shot, except of that for brass ordnance for which wood was to be retained. On 25 January 1866 a further change was ordered; the canister of the case shot of 32-pounder, 8-inch, 10-inch, and 68-pounder guns was to be a hollow iron rather than tin cylinder closed by two iron ends. This design was later extended to case shot for 8- and 10-inch howitzers.

Thus, by the mid-1860s there were three classes of case shot. Class III was standard for all brass ordnance, whether guns or howitzers, and for all iron ordnance below the 12-pounder (inclusive), as well as the 5-1/2-inch iron howitzer. The canister was a tin cylinder with a tin top soldered on (that is, thin sheet iron tinned over). The bottom was wooden secured by tin tacks, 4 inches apart, the heads soldered over to hold them in place and to prevent their scoring the bore. Projecting below the canister, the bottom varied in shape depending on the nature of the piece's chamber. To fit the Gomer chambers of the 32-, 24-, and 12-pounder howitzers (and for the 12-pounder gun even though it was not Gomer chambered) the bottom was connical; to fit the chambers of the 5-1/2- and 4-2/5-inch howitzers it was hemispherical; and for the remaining guns, the 9-, 6-, and 3-pounders it was cylindrical. None of these case shots had a handle except that for the 32-pounder howitzer which, because of its weight, was fitted with one of rope.

Class II case shot, which had been approved in 1861 for all other ordnance, was identical to Class III, except it was fitted with a bottom of sheet iron rather than of wood. The edge of the open end of the cylinder was fringed, and this fringe was hammered over the edge of the iron bottom to secure it in place. A rope handle was attached to the bottom for ease in lifting.

Class I case shot, approved in 1866 for the 32-pounder, 8-inch, 10-inch, and 68-pounder guns, was composed of a sheet iron cylinder with sheet iron ends. Its top was fitted with an iron handle. The bottoms of the 10- and 8-inch case shot were slightly rounded to fit the chamber better and to ensure that the cartridge was set home in simultaneous loading. This variety of Class I case shot was designated Pattern II to distinguish it from Pattern I which was really the older Class II case for these particular calibres. After the approval of Pattern II, it was obsolete but it continued to be re-issued to the land service if it was serviceable. Pattern II case shot for the 8-and 10-inch guns was also issued for the corresponding howitzers.[159]

Earlier sources had indicated that sea service case was painted red and that land service case was not painted, but by 1861 the Ordnance had decided that case for guns and carronades was to be painted red and for howitzers black. The Pattern II case which was issued for the 8- and 10-inch howitzers was gun case and was therefore painted red.[160]

It should be noted, a point which Majendie made emphatically, that the rope handles of Class II and III case shot were attached for convenience in lifting but not for swinging up into the piece; the handles, which were attached to the bottoms, were placed next to the powder charge. This seemingly was not true of Pattern II case shot whose iron handle was attached to its top.[161]

Spherical Case Shot or Shrapnel Shell

Spherical case shot or shrapnel shell, its official designation after 1852, was a shell filled witn carbine or musket balls, containing a bursting charge and fuze with which to explode it. Its purpose was to give the effect of case or grapeshot at the extreme range of artillery where, until its advent, only round shot was effective. The bursting charge was small, sufficient only to open the shell casing, thereby releasing the carbine or musket balls in an expanding cone which descended onto the target. Because the bursting charge was so small, the trajectory and velocity of the balls were determined, not by the explosion of the bursting charge, but by the service charge and elevation when the gun was fired.

Although claims have been made that German artillerists in the sixteenth century and French gunners in the seventeenth century understood and applied the principle of the shrapnel shell, its invention is usually attributed to Henry Shrapnel, an officer of the Royal Artillery.[162] Even though he was not present at the siege of Gibraltar in 1781, he appears to have learned from the experience of the gunners there. Round shot fired from batteries high on the rock had proved ineffective against the beseigers in their works on the isthmus below. Also, because of the smallness of the service charge, shells fired from howitzers had neither the accuracy nor the force to do much damage; moreover, the explosion of the bursting charge scattered the splinters ineffectually over a large area. Finally long 24-pounder guns were substituted for the howitzers and 5-1/2-inch shells with short fuzes were fired from them with as large a service charge as the shells could sustain. When the shells burst over the heads of the beseigers, the high velocity imparted by the discharge of the gun drove the fragments forward with greater force than before, and their dispersion was less because of the preponderance of their velocity over the force of the bursting charge. The result proved extremely destructive to the enemy troops.[163]

It is not clear precisely when Shrapnel first conceived the idea of his shell. In 1813 he wrote ".. Notwithstanding it is nearly 30 years ago since I first exhibited the firing of balls in 'metal cases.' "[164] Hogg and Hughes in their studies of British artillery accepted 1784 as the date of the proposal or invention of spherical case shot.[165] The author of the biographical notice in the Dictionary of National Biography agreed:

> ... in 1784... he [Shrapnel] began, at his own expense, to make experiments and to investigate the problems connected with hollow spherical projectiles filled with bullets and bursting charges, and with their discharge from the heavy and light ordnance of the time...[166]

His investigations bore fruit for in 1787, when he was stationed at Gibraltar, he demonstrated before the commander, Major-General O'Hara, "... a new method of extending the use of grape shot, to the utmost range of ordnance."[167] His firing of an 8-inch mortar shell loaded with 200 musket balls and 1 lb. 3 oz. of powder which exploded just above the water favourably impressed O'Hara. In February 1792, Shrapnel made proposals to the Board of Ordnance for firing grape and case shot "... in a more collected manner." The Board responded by convening a committee of officers to consider the proposal, but there is no record of its findings. Indeed it was not until 7 June 1803, following other trials, that there was a favourable but cautious recommendation to the Board of Ordnance.[168]

Perhaps as a result of the invasion scare following the failure of the Peace of Amiens, orders for shrapnel shells were placed with the Carron foundry in Falkirk, and in August 1803 the Board of Ordnance sent Shrapnel north to test the production. Many of the shells were sent to Ireland, but others went to various English posts in response, it seems, to requests from local commanders rather than as part of an overall Ordnance policy. The evidence is limited, but it appears that initial acceptance, at least by those in high positions, was restrained. In addition to Shrapnel's own endeavours, Sir John Sinclair, the agricultural reformer and statistical enthusiast, busily importuned soldiers and politicians to adopt the new shells into general service.[169]

However limited official recognition was, the new weapon achieved some success in various minor engagements. The first recorded instance was in April 1804 against the Dutch settlements of Surinam in South America. In 1806 British forces used it at the Cape of Good Hope, in Italy, and in Egypt; in 1807 it saw service outside Copenhagen with the British force supporting the naval action against the Danish fleet. At Rolica and Vimiero in August 1808, at the beginning of the Peninsular war, the artillery put the new shell to such effective use that it drew the praise of Wellington himself; it continued to be issued throughout the remainder of the war, and was used at Waterloo in 1815.[170]

The slowness to accept Shrapnel's invention may be attributed to wrong-headedness or to inherent conservatism, but it may also have been due to a realistic recognition of the problems of the new weapon, some of which were not successfully resolved until the late 1850s. As early as 1804 the Committee on Ordnance conducted experiments "... for the purpose of ascertaining the causes of some of his [Shrapnel's] shells failing, and bursting in the bores of the pieces of ordnance..." In response, Shrapnel convinced the Committee that the fuzes were at fault, and he modified and improved them to its satisfaction.[171]

Undoubtedly the improvement of the fuzes increased the efficiency of the shells, but Shrapnel never solved the recurring problem of premature bursts. While he recognized "... that the ignition of the bursting powder was sometimes caused by the reaction of the balls on the inside of the shell...," he did not arrive at a satisfactory method of separating the balls from the bursting charge. He may have driven the balls into the shell as tightly as possible, and then removed a few to make a space for the bursting powder, but this solution, while perhaps marginally succesful, was not adequate.[172]

Other problems were solved more successfully. Though Shrapnel initially experimented with mortar shells, the shrapnel shells adopted were thinner skinned than these, or indeed than common shells. Consequently at first a much reduced charge was used to fire them; thus their range and therefore their usefulness was much decreased. In 1813, however, it as reported that:

> Lt.-Col. Shrapnel has proved by experiments, that spherical case shot for all natures of field ordnance may be fired with effect with the service charge for round shot.[173]

Certainly by the 1820s the practice was to use the standard service charge to fire spherical case shot.[174]

Another problem which Wellington himself raised was the effectiveness of the balls contained in the shell. Shrapnel had recommended carbine rather than musket balls (calibre 0.6 inch as opposed to 0.68 inch), presumably because more of them could be packed into a shell, while at the same time he felt that the lighter ball still had adequate penetrating power. In 1812, Wellington, who previously had a high opinion of the shells, found that they were defective in that "... they inflict trifling wounds, and kill nobody..." In consequence of his criticism, and on his and his senior artillery officers' recommendation, musket balls were substituted for carbine balls thereafter.[175]

Following the Napoleonic wars, Shrapnel continued his experiments attempting to perfect his shell, but, after extensive tests at Woolwich in 1819, the Ordnance lost interest in the problem for reasons of economy.[176] Despite its imperfections, spherical case shot was used effectively in India and South Africa during the next three decades.[177] It was not until 1849, when Captain Edward M. Boxer, who later was appointed Superintendent of the Royal Laboratory, became aware of the problem of the premature bursting of the shell, that the Ordnance once again began to take a serious look at its defects.

At first Boxer attributed the cause of the premature bursts to faulty fuzes and he designed a new fuze to overcome their failing. Tests conducted in 1849 convinced him that the fault lay not with the fuze but with mixing the bursting charge among the lead balls; heat generated by the friction of the balls working against each other or against the wall of the shell ignited the bursting charge. Various expedients were tried to eliminate this reaction — coating the interior of the shell with cement; fixing the balls with pitch, sulphur, or plaster of Paris; reducing the service charge — but all proved unsuccessful. Boxer argued that the balls and the bursting charge should be separated and his suggestion of putting the latter in a canvas bag within the shell eliminated premature bursts. In 1849 Boxer failed to convince his colleagues — they successfully argued for a reduction of the service charge — and it was not until 1852 that he again got the chance to demonstrate the soundness of his opinion.[178]

Boxer's achievement was not only in recognizing the cause of the premature bursts of the Shrapnel shell but also in redesigning it without sacrificing its principle of action which Henry Shrapnel had perceptively understood 70 years before. Using a canvas bag to contain the bursting charge separated it from the balls, but, because this arrangement placed the charge toward the middle of the shell, the explosion tended to scatter the balls in all directions rather than just releasing them unto their target. Boxer overcame this difficulty by introducing a wrought iron partition or diaphragm into the interior of the shell to divide it into two unequal sections, thus keeping the bursting charge, contained in the smaller section, to one side of the balls rather than among them. Because the shell was weakened where the diaphragm was

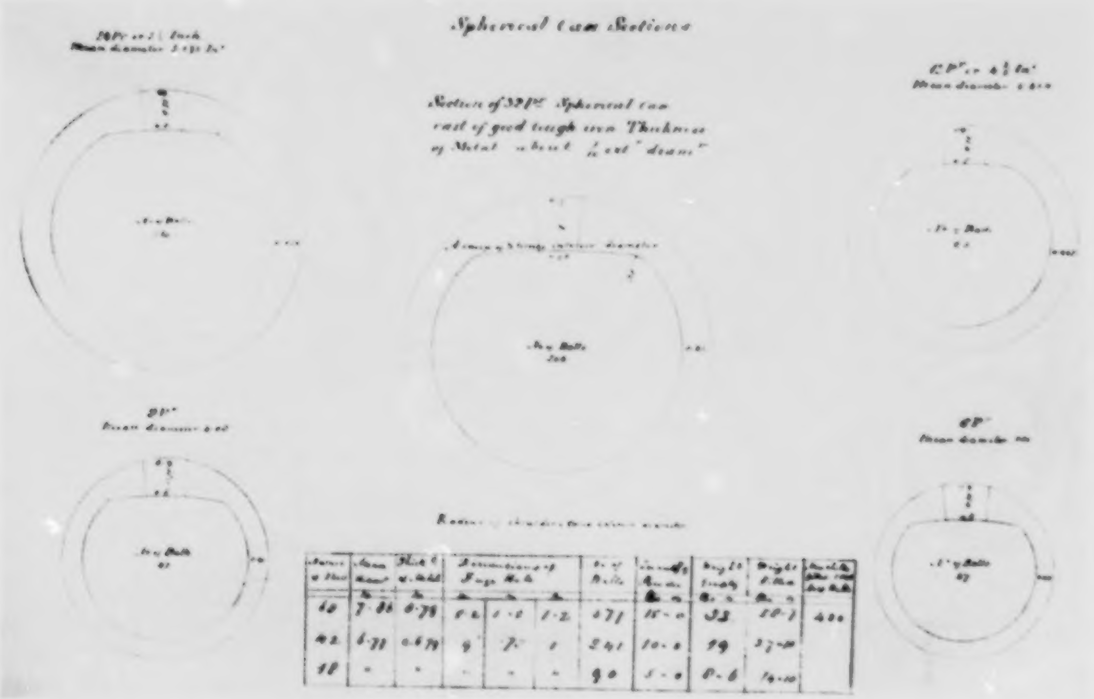


Figure 214. Spherical Case Sections. (The Royal Artillery Institution, Woolwich, U.K., Strange, "Drawings on Artillery.")

joined to it, there was a danger that it would be fractured at points of least resistance into two sections, the balls remaining in the larger section without being released properly. To counteract this tendency Boxer strengthened the shell wall by thickening it at the juncture points. At the same time he made four tapering grooves in the interior, extending from the fuze hole to points near the bottom of the shell; these created lines of least resistance along which the shell was opened and the balls were little affected by the explosion of the bursting charge. Experiments with this design of shell in 1852 and 1853 were successful, and on 11 October 1853 Boxer's diaphragm shell was provisionally approved for service.[179]

Once Boxer had demonstrated that the mixing of the balls and the bursting charge in the original shrapnel caused the premature bursts, the Ordnance was faced with the problem of what to do with the large supply of old shells in store. As well, the deteriorating situation in the Balkans that led to British involvement in the Crimean War created a demand for the shells that was greater than could be supplied by the newly approved diaphragm shrapnel. In September 1853, Boxer proposed a solution:

> As there are a great number of shrapnel shell now in store, I beg to say that having now for so long a time turned my attention to the subject, I can with confidence undertake to prepare these shells in such a manner as to prevent the defect of premature explosion, although it will be impracticable to make them as efficient as the diaphragm shell.[180]

He suggested separating the balls and bursting charge by placing the powder in a tin cylinder which was in the continuation of the fuze hole. This design overcame the problem of premature bursts, but, because the bursting charge acted through the balls, it tended to scatter them more than was desirable. Also, the explosion crushed the balls, even when hardened with antimony, against the side of the shell at the moment of rupture, thereby reducing their velocity and striking force. Despite these defects, because of the large number in store and because of the anticipated war in eastern Europe, what was called "improved shrapnel" was approved on 23 March 1854, although the detailed instructions for converting the old shells were not actually promulgated until January 1855.

Improved shrapnel was the original shrapnel shell fitted with a gun-metal fuze socket attached to a tin cylinder to hold the bursting charge. The socket was screwed into the fuze hole, projecting about 0.2 inch above the surface of the shell. Its bottom was closed except for a small fire-hole through which the flame from the fuze reached the bursting charge in the tin cylinder. Its interior was slightly conical and tapped with a right-handed thread that served to hold the improved shrapnel fuze more firmly. A gun-metal plug with a plug of wood covered with serge attached was screwed into the socket to block the fuze-hole to prevent any powder getting into the socket before the shell was prepared for action. The tin cylinder was soldered to the socket as its continuation and extended through the shell, but it was not in contact with the bottom of the shell.

A loading hole through which the balls were put into the shell was drilled near the fuze hole and closed with a gun-metal screw plug. The hole was small for the 6-, 9-, and 12-pounders which were filled with carbine balls and large for the other natures which contained musket balls. As well, a pistol ball and a buck shot were added when the complement of large balls had been put in. The balls were cast of a mixture of lead and antimony (six parts lead to one part antimony) to harden them to prevent their conglomerating when the shell burst. Resin was poured in among the balls to assist in this. Also, it embedded the balls not allowing them to press against or to break the tin cylinder. Being brittle when cold, it broke up when the shell burst, thereby releasing the balls.[181]

Boxer was aware that the provisional pattern of diaphragm shrapnel approved in 1853 was not completely efficient, but because of the pressure of the developing war against Russia in the Crimea, he did not have the chance to conduct the necessary experiments to perfect the details of the shell. Some of the deficiencies he attributed to the inexperience of the contractors who were manufacturing the shells, others to details of design; even so, he believed that "... the effect of these shells is nevertheless very destructive." Following the war he continued to perfect the diaphragm shell and on 29 December 1858 his new pattern was provisionally approved.[182]

The most important difference between the 1853 and 1858 patterns was the manner of attachment of the diaphragm to the interior of the shell. In the 1853 pattern the complete rim of the diaphragm had been cast into the shell. Consequently, the diaphragm provided sufficient resistance to the explosion of the bursting charge that the shells tended to fracture round this juncture, often preventing the proper release of the balls. The diaphragm adopted in 1858 was joined to the shell by four projections equidistant from each other of a strength just sufficient to resist the shock of discharge. Thus, it provided much less resistance to the explosion of the bursting charge, and the shell was more likely to open along the lines of least resistance, that is the four tapered grooves. To fill up any space between the diaphragm and the side of the shell (and around the fuze socket [see below]), thereby preventing any leakage of powder out of the powder chamber into the ball chamber, the interior of each chamber was coated with Jeffrey's marine glue.

The diaphragm had a hole in its centre to allow for the insertion of the gun-metal fuze socket which was screwed flush into the shell. The socket's internal diameter and shape, which were designed to take the diaphragm shrapnel fuze, were the same as those of the fuze hole of the common shell, but somewhat larger and more conical than those of the improved shrapnel socket. A fire-hole pierced one side of the socket to allow the flame from the fuze to pass to the bursting charge. To aid its passage the socket was constructed to be slightly longer than the fuze, and a shallow groove was cut up to the hole from the bottom of the socket. It was tapped for about 1 inch to take a gun-metal screw plug with a wood plug covered with serge that closed the socket before the shell was prepared for action. The screw-threads also secured the fuze more firmly. The bottom of the socket was open to allow the balls to be put in; it was then closed with a gun-metal screw plug.

To one side of the socket hole a loading hole was drilled into the powder chamber through which the bursting charge was poured in. It was of two sizes, small for calibres up to 18-pounder (inclusive), and large for those above. It was closed with a gun-metal screw plug.

There were other minor improvements in the 1858 pattern. In all natures of the shell above the 12-pounder the bottom of the shell was thicker than the sides to withstand the shock of discharge. Such thickening was not necessary for the lesser natures because the service charge was relatively light. The thickness of metal around the fuze hole was also increased to afford proper support to the socket. Also, after 1858, the socket was screwed in flush rather than projecting above the surface of the shell.[183]

It was noted above that originally Shrapnel had filled his shells with carbine balls, but that, on the advice of of Wellington and other artillery officers, musket balls were substituted in 1812. This appears to have remained the practice until the 1850s, when once again carbine balls were re-introduced but only for the lighter nature of diaphragm shells from 6- to 12-pounders (inclusive). In addition, one pistol ball and one buck shot were inserted into all calibres when the requisite number of the larger balls had been added. Also, in order to harden the balls, the lead was mixed with antimony (six parts lead, one part antimony); the hardening reduced a tendency of the balls to lump together or to lose their shape, which decreased their effect. To help prevent this lumping together coal dust was shaken among the balls to fill up the spaces.[184]

Following the provisional approval in 1858 there was a delay of six years before final approval was given. Presumably tests were conducted on the shell, but except for an increase in the amount of bursting powder in all natures except the 6-pounder no other changes seem to have been made.[185] Final approval of the adoption of the diaphragm shrapnel shell was given on 27 September 1864.[186]

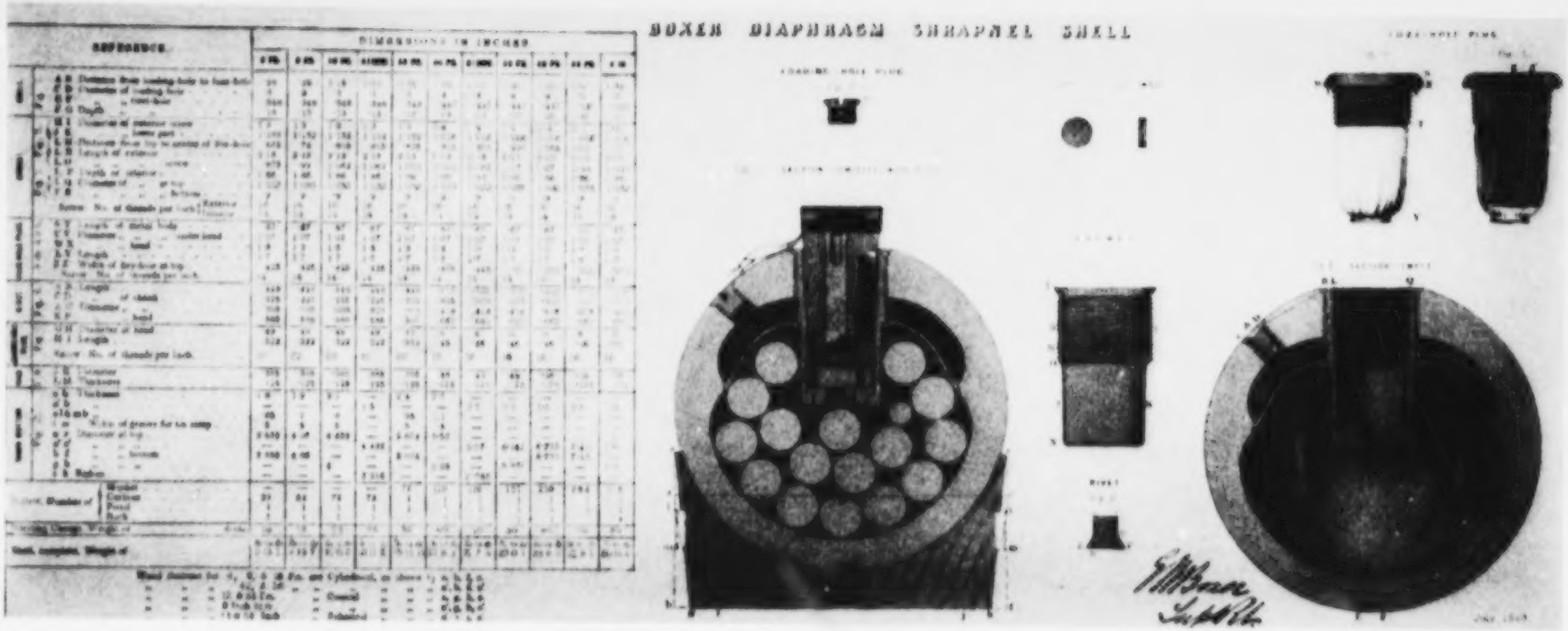

BOXER DIAPHRAGM SHRAPNEL SHELL
REFERENCE
DIMENSIONS IN INCHES

Figure 215. Boxer Diaphragm Shrapnel Shell. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate 24, July 1863.)

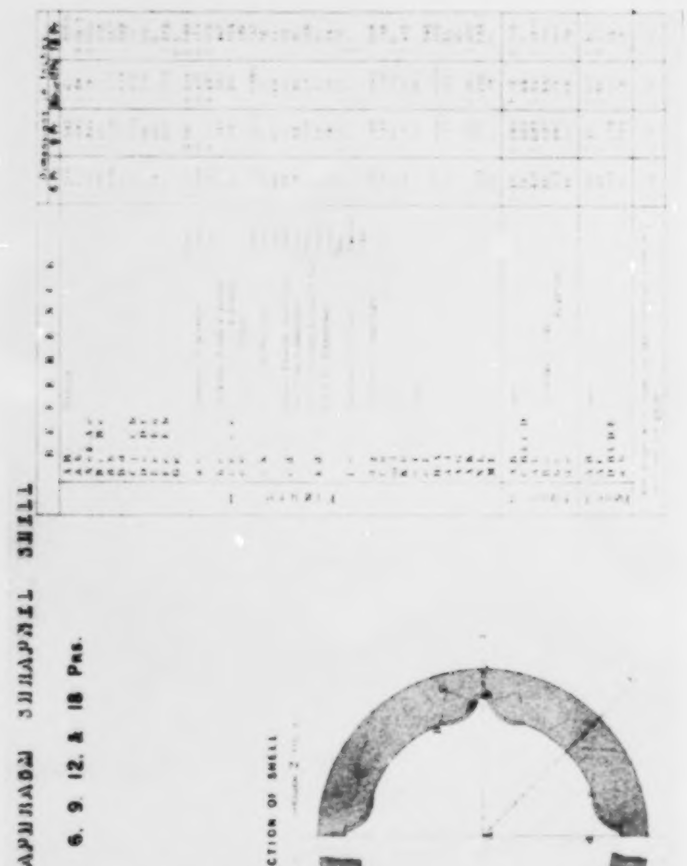

BOXER DIAPHRAGM SHRAPNEL SHELL
6, 9, 12, & 18 Prs.
PLAN OF DIAPHRAGM
SECTION OF SHELL
SECTION OF SHELL

Figure 216. Boxer Diaphragm Shrapnel Shell, 6, 9, 12, & 18 Prs. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate 21, March 1863.)

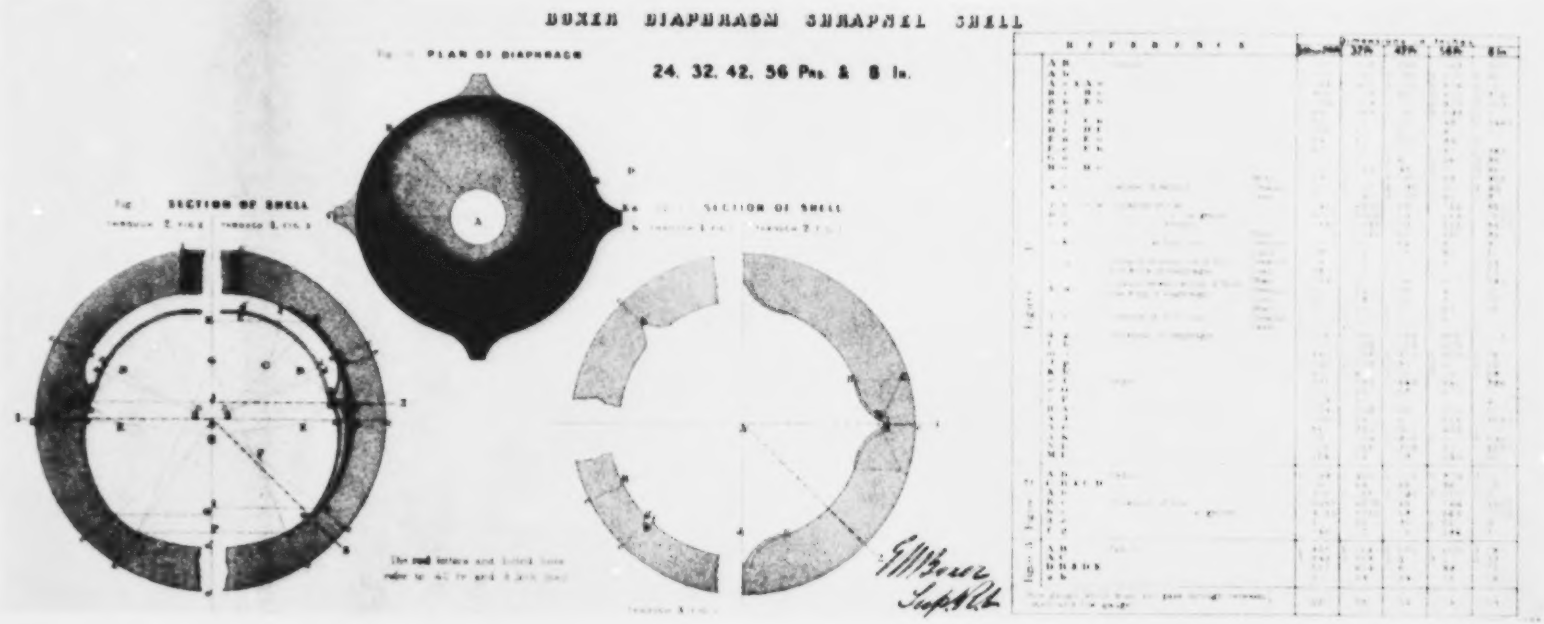

BOXER DIAPHRAGM SHRAPNEL SHELL
24, 32, 42, 56 Prs. & 8 In.
PLAN OF DIAPHRAGM
SECTION OF SHELL
SECTION OF SHELL
REFERENCES

Figure 217. Boxer Diaphragm Shrapnel Shell, 24, 32, 42, 56 Prs. & 8 In. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate 22, April 1863.)

FUZES

A fuze was the means of igniting the bursting charge of a shell. It was so designed that it could effect this ignition at any particular time, during flight, on or after impact.[1]

The earliest fuzes were pieces of quickmatch stuck into a hole in the shell casing. This was replaced by a tube containing a mixture of saltpetre, sulphur, and mealed powder which would burn at a predictable rate. Initially the tube was iron, but beechwood (or sometimes hornbeam) was eventually adopted. No precise date can be given for the introduction of beechwood, but there is a record of experiments carried out with shells and fuzes in 1743-4 in which, because of their weight, the fuzes must have been made of wood, probably beech.[2] The recognized authorities agree that by 1750 beechwood fuzes were the standard issue and so continued until the end of the smooth-bore era.[3]

From about 1750 until Boxer's improvements in the early 1850s, the common wooden time fuze remained remarkably unchanged. A tapering tube of beechwood, with an enlarged head until about 1830, it came in five sizes corresponding to the five shells fired from mortars and howitzers – 13, 10, 8, 5-1/2, and 4-2/5 inch (Figs. 218, 219, and 220). A bore was drilled along its axis, almost but not quite through, and this bore was filled with a composition of saltpetre, sulphur, and charcoal, moistened with spirits of wine and driven hard. The upper part of the bore was enlarged into a

Figure 218. Old Pattern Fuze for 13-inch Mortar Shell. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXII/2.)

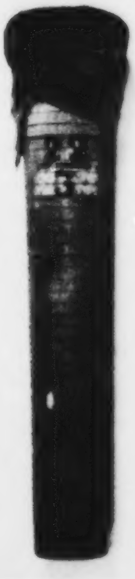


Figure 219. Old Pattern Wood Fuze for 10-inch Mortar Shell. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXII/3.)

shallow cup which was primed with quickmatch and mealed powder moistened with spirits of wine. A cap of paper or canvas was then tied around the head.

When the fuze was to be inserted into the fuze hole of a shell, it was cut off at the length required for its time of flight. Early authorities state that this cut should be made at an angle, presumably to provide a slightly larger surface to transfer the fire from the composition to the bursting charge in the shell.[4] Before insertion the cap was removed, the fuze was rasped to ensure that it fitted properly, and flax was wrapped around it to prevent the flame of discharge entering the shell and exploding it prematurely. The fuze was put in by hand, and then set firmly with a setter and a mallet, care being taken not to split the wood, since a split could result in the shell bursting prematurely.[5]

To prepare a fuze, beechwood was cut into the required sizes, then rough turned to the required shape and bored. These rough turnings were then stored and dried for several years.[6] Although the authorities do not mention it, presumably when the fuzes were to be filled with composition they were once again turned and bored to their required size before going to the laboratory to be filled and primed for use. Although all contemporary documents do not agree, a set of dimensions seems to have prevailed until about 1830. (See Appendix TTT). In the late 1820s or early 1830s minor changes were made in the dimensions of fuzes, principally in the elimination of the enlarged head, the fuze henceforth tapering continuously from top to bottom. (See Appendix UUU). These dimensions remained in effect until about 1850.

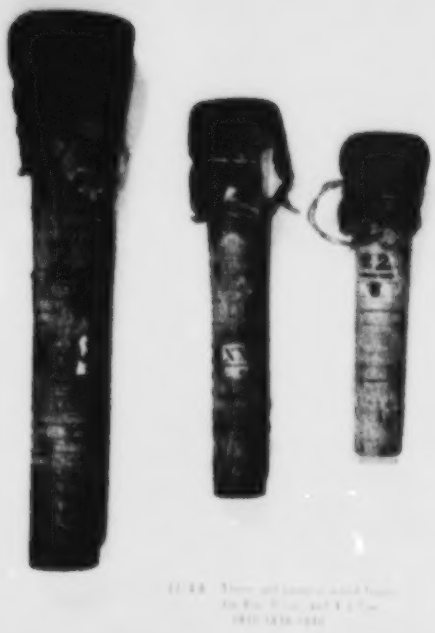


Figure 220. Three Old Pattern Wood Fuzes for 8-in., 5-1/2-in. and 4-2/5-in. Mortar Shells, 1815, 1838, 1840. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXII/4-6.)

Fuze Composition

Throughout the period under study the fuze composition was composed of a mixture of saltpetre, sulphur, and mealed powder. The earliest sources list a number of variations of the mixture. One practice book noted that General Borgard, presumably about 1720, recommended different proportions of the ingredients, depending on the nature of the shell.

	13in.,	10.in.	L.S.	13in.,	10.in.	S.S.	Howitzer & 8in.		
	lbs.	ozs.	drs.	lbs.	ozs.	drs.	lbs.	ozs.	drs.
saltpetre	3	8	0	3	0	0	2	8	0
sulphur	1	0	0	1	0	0	1	0	0
mealed powder	3	8	0	3	0	0	2	8	0[7]

The different proportions probably affected the speed at which the composition burned.

Both Muller in his *Treatise of Artillery*, and Smith in his *An Universal Military Dictionary* (in which he seems to be copying from Muller), noted that the proportions of the ingredients may be varied – saltpetre, three parts; sulphur, one part; mealed powder three, four, or five parts "... according as it is required to burn quicker."[8] A quicker burning composition would be called for if the use of a slower burning composition necessitated cutting the fuze so short that it could not be fitted properly into the fuze hole. A second method to achieve the same result was to cut the fuze long and then drill out the fuze composition to the required length, thus allowing the fuze to be fitted properly.[9]

Despite a record of some variation in the early period, one mixture of fuze composition consistently appeared in the various notebooks and manuals from *circa* 1750 to 1867.

	lbs.	ozs.
saltpetre	3	4
sulphur	1	0
mealed powder[10]	2	12

A note in Adye in 1813 says that mealed powder alone may be used for short distances since it burns twice as fast as composition, but other than this the above composition remains constant for at least 100 years.[11]

Although detailed descriptions of the manufacture of common wood fuzes do not appear until about 1800, it is clear from earlier, briefer accounts that in all essentials the method remained the same from about 1750 until Boxer's innovations in the 1850s.[12] Before 1750 very little information on fuzes has survived. The following description, which has been abstracted from various manuals written around 1800, may be considered accurate for the century after 1750.

Mixing the fuze composition was the first step. The proper proportions of the ingredients (saltpetre, sulphur, and mealed powder) were carefully measured out into a leather bottom and brought to the mixing table. On it they were combined by hand and with a wooden rubber. Then the mixture was passed first through a hair sieve (using a copper slice to force through the larger grains) and second, through a lawn sieve to make it even finer. Lastly the composition was spread out on the table and mixed some more with a copper shovel. It was essential that the ingredients be as well mixed as possible.

Once mixed, a proportion of the composition was put into a small square box to be taken to where the fuzes were to be driven. (The two areas of mixing and driving were usually separate to mitigate the effects of an accident in one or the other.) The fuzes were driven on a large block of elm with holes drilled into it to hold metal sockets into which the empty fuzes were secured with a small piece of leather. Once the fuze was in place, a ladle-full of composition was put into the fuze bore. For each size of fuze a particular size of ladle was used. (Since it was essential that the same amount of composition be put in each time, a small piece of wood or something similar was used to remove excess composition above the edges of the laddle.) Then the longer of two iron drifts, each tipped with brass or copper, was introduced into the bore and the appropriate number of blows given with a wooden mallet, the drift being turned in the fingers as the operation progressed. This was repeated until the bore was almost full, about 1/10 inch from the top. It was then gauged with the appropriate instrument and the level of the composition marked on the outside of the fuze. (It was from this point that the appropriate length was measured when the fuze was cut.)

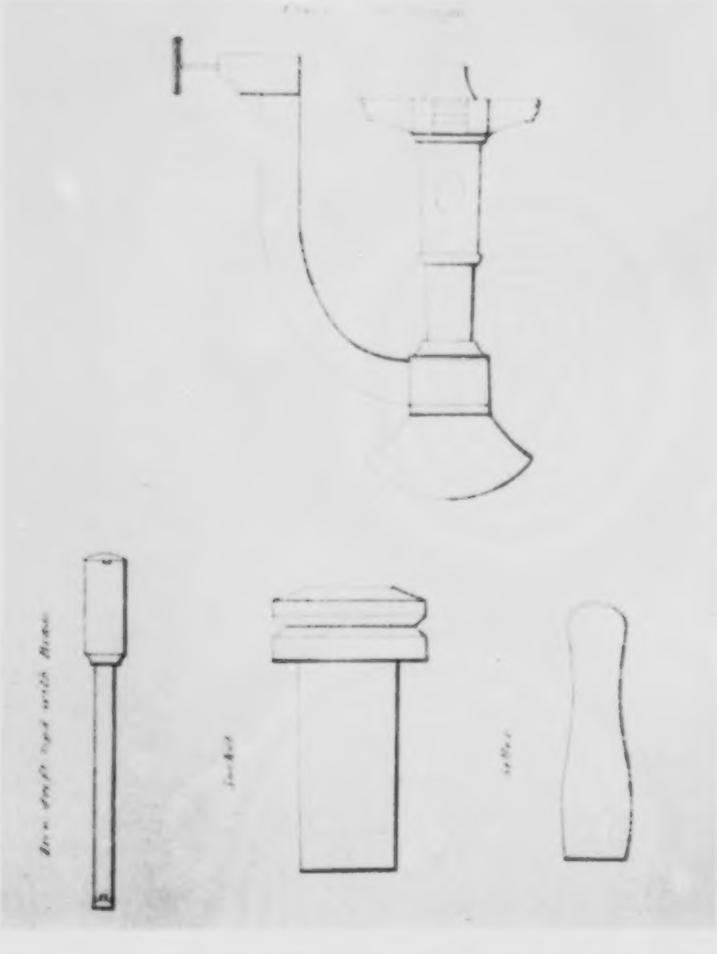


Figure 221. Implements necessary for Driving Fuzes. (The Royal Artillery Institution, Woolwich, U.K., "Artillery Implements...")

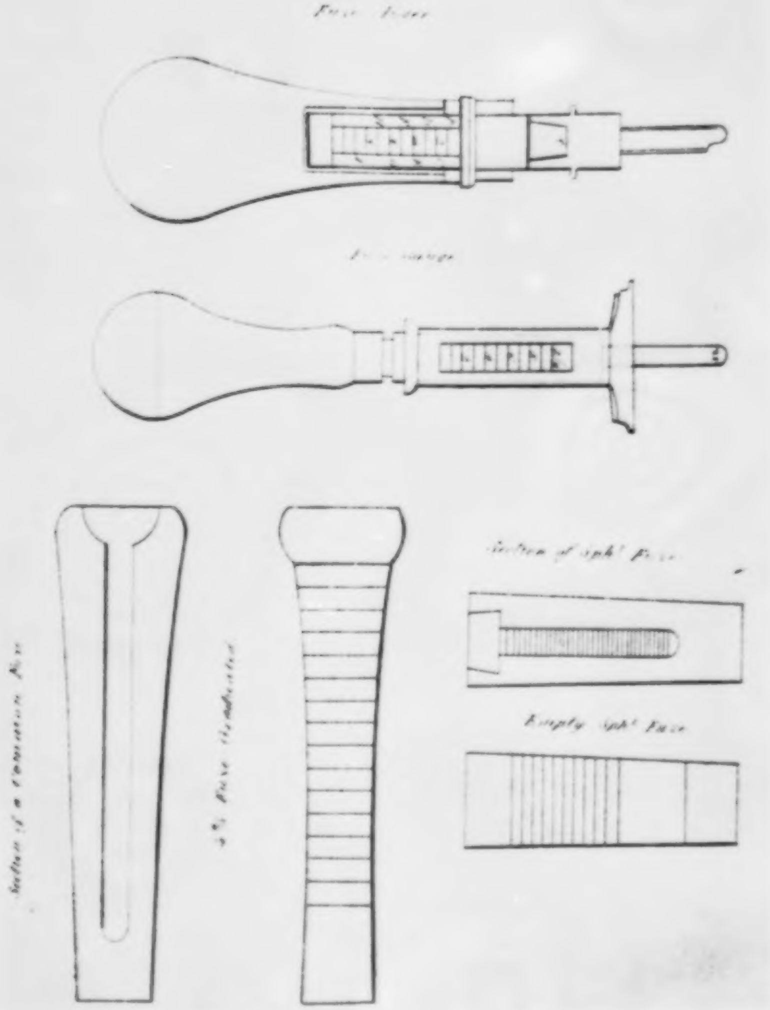


Figure 222. Fuze Auger, Fuze Gauge, and Fuzes. (The Royal Artillery Institution, Woolwich, U.K., "Artillery Implements...")

Next the fuze was primed with quickmatch and mealed powder. The upper surface of the driven composition was then scratched and loosened slightly with a brass pricker. The appropriate length of quick match was taken, gently doubled, and the doubled end put into the bore on top of the loosened composition. The shorter drift was inserted and two or three gentle blows given to secure the quick match. Finally a ladle of mealed powder was poured in and driven down with the same number of blows as for the composition.

Mealed powder was mixed up stiff with spirits of wine. (Later sources specify cylinder mealed powder rather than pit mealed powder, the difference being in the method of making the charcoal in the powder.) The ends of the quick match were curled inside the fuze-cup which was then filled with the dampened mealed powder, well pressed down by a finger. The cup was dipped in dry mealed powder and the fuze was placed in a tray to dry for three or four days.

Once dried the fuze was capped. A circle of curred (that is, especially treated) paper of the proper size was punched out of a sheet and placed on top of the cup. Over that a square of brown paper or canvas (canvas is prescribed as an alternative after 1800) was placed, turned down, and pleated round the head of the fuze. It was secured with two turns of twine below the shoulder. The paper was cut off about 1/10 inch below the twine and turned up by striking with the edge of a knife to prevent the twine from slipping off. Finally the paper or canvas was covered with two coats of paint and the date when the fuze was made painted on.[13]

Fuzes for Spherical Case (Shrapnel Shells)

The development of the spherical case (shrapnel shell) in the first decade of the nineteenth century necessitated a new fuze to meet its requirements. There were two sizes, the 8-inch and the 5-1/2 inch, the former to be used in 32-pounder shells and above, the latter in 24-pounder or 5-1/2-inch shells and below. Like the common fuze, it was made of beechwood in the shape of a frustum of a cone, but it lacked the enlargement of the head. According to dimensions printed in 1827, the two fuzes varied in their lengths, although the depths and diameters of their cups were the same. Dimensions of about 1850 showed more slight variations in size.[14] The bore, the diameter of which was the same as that of the fuze of the 8-inch or 5-1/2-inch common shell, was threaded to hold the composition more firmly.[15]

The preparation of the spherical case fuze was similar to that of the corresponding common fuze. The composition was the same, and the method of driving and the tools used were those prescribed for the common fuzes. It is assumed that it was gauged in the same way as the corresponding common fuze. Unlike the latter, the spherical case fuzes were calibrated in tenths of an inch from their inception.

On the other hand, the method of quickmatching was different. Four holes were drilled through the sides of the cup, presumably dividing the cup into four equal sections. One length of quick match was doubled and secured in the cup in the usual way. Then two other pieces were inserted through the holes in the side of the cup so that they crossed in its middle. The next step in which the quick match was secured by catgut was not described very clearly in the sources. One notebook said:

> A piece of Catgut is then taken [,] the two ends passed through
> 2 adjacent holes and another piece of quickmatch is placed in
> the loops of the Catgut which is then drawn tight & fastened
> by a treble reef knot on the outside.[16]

The additional lengths of quickmatch were to increase the probability that the fuze would ignite.

The fuze was then primed with a paste of mealed powder and spirits of wine, on top of which a circle of cured paper was placed. It was finished off with a cap of brown paper, tied down undoubtedly in the same way as the caps of the common fuzes.[17] Each fuze was marked with a stripe of a specific colour on two sides and with a letter of the same colour on the cap to indicate the range for which the fuze had been cut or bored before it was issued.

Whether the fuze was cut or bored is not precisely clear. It could be sawn off at the prescribed calibration, but a very short fuze probably could not be fitted into the fuze hole properly. Instead, with a special tool, a fuze auger, a hole was bored from the side of the fuze into the composition at the prescribed calibration and the hole was primed with quick match. The fire would pass down the composition to the bore hole and then along the quick match into the bursting charge, thereby exploding the shell. A practice book described a process in which, as well as the hole being bored, a groove was cut around the fuze, quick match put in and held in place by a piece of flax pasted on until the fuze was to be placed in the shell.[181]

Reform

A major problem with the common fuzes, and with the shrapnel fuzes if they were cut rather than bored, was that the composition was unsupported once the fuze was cut for insertion into the fuze-hole of the shell. When the shell was discharged from the piece, the burning composition, due to its own inertia and the pressure of air against it, was often set down into the shell, causing a premature explosion. In 1849 Captain E.M. Boxer submitted a new fuze design to the Board of Ordnance, in which the fuze was no longer cut off, but bored into from the side. In addition to the composition channel bored from the top, he added a smaller second channel to one side bored from the bottom. Into this second channel he drilled a series of holes 2/10 inch apart. This channel was filled with mealed powder. The holes, except the bottom one, were plugged with pressed powder and putty. When the fuze was prepared for use, one of these channels was bored out (depending on the length of time the fuze was to burn), and the hole extended into the composition channel. When the fuze was ignited by the firing of the shell, the composition burned down to the bored-out side hole. If it opened inside the shell, the fire could pass directly to the bursting charge. If it opened against the shell wall, then the fire ignited the powder in the small channel, passed down it and out through the open bottom hole to ignite the bursting charge. In the first instance, of course, the fire passed into the shell through both passages. After this design was tested successfully at Woolwich and Shoeburyness in September 1850, it was approved for use in shells fired from guns and howitzers; mortar shell fuzes remained unchanged.

Because the side holes were 2/10 inch apart, it was necessary to have two fuzes for each shell, one with even, and the other with odd, tenths marked. The paper caps were painted as an aid in distinguishing between them, the even-tenths black, the odd-tenths white. This awkward situation remained unchanged for almost two years, when Boxer proposed certain alterations in design. In effect he combined the two fuzes into one, by employing two powder channels and two rows of holes, one for odd and the other for even tenths, and, to allow room for them, by drilling the composition channel off centre.

Over the next year Boxer continued to refine his design. To afford support to the powder in the powder channels, which had been held in place only by a paper disc pasted on the fuze bottom, he inserted pieces of quick match into the bottom holes of each row. In order that the bursting charge would be ignited even if the fuze was not bored or if it was improperly bored, he drilled the bottom holes of each channel through into the composition, an additional hole being added to the odd-tenths row to ensure that the time of burning not be shorter than 10 seconds. Also, he made other minor changes in quick matching and priming. Of particular note, and considered very important and distinctive of Boxer fuzes, a hole, at first 1/10 inch in diameter, then 1/8 inch, was drilled into the upper surface of the composition. This simple expedient ensured ignition by exposing a greater area of composition to the flame. These improvements were successful, and early in 1854 Boxer's fuzes of two powder channels were approved, one of 1 inch of composition for Shrapnel shells and one of 2 inches for all shells fired from guns and howitzers.

In March 1854, the projecting head of the fuze was streamlined so that the fuze fitted more closely to the surface of the shell and was less likely to be knocked out on ricochet. It was shortly found, however, that this improvement raised a new difficulty. Because of the straightness of the cone or the shrinking of the wood, or both, many fuzes were being set into the shell by the shock of discharge, thus causing premature explosions. Boxer's solution was to increase the angle of the cone. His recommendation was accepted, and his "large cone" fuze with a new metal cap was officially approved for the service on 18 August 1855. After that no substantial changes were made in Boxer's wood time fuze for common and Shrapnel shells.

A mortar fuze on the Boxer principle, for 8-, 10-, and 13-inch shells, was not introduced into service until 27 January 1855. Initially this was a "small cone" fuze, subject to the danger of being set into the shell on discharge, but a "large cone" version was developed and accepted into service on 18 August along with the shrapnel and common fuzes. The small mortar fuze, for 5-1/2- and 4-2/5-inch shells seems to have been developed about the same time and underwent the same progression from "small" to "large cone." Both mortar fuzes had metal caps.[19]

Boxer's Common Fuze

This fuze was a truncated cone of beechwood about 3 inches long, with a diameter at its top of about 1 inch (Fig. 223). The slope of the cone was about 0.11 inch in 1 inch. A cup 0.25 inch deep was hollowed out in the top of the fuze. Four holes, which were connected by a shallow groove on the outside, were bored through the sides of the cup. The composition channel, slightly more than 0.25 inch in diameter, was bored through the cup almost to the bottom of the fuze, somewhat off centre but parallel to its axis. Fuze composition was pressed or driven into this channel until it was filled up to the cup.

Two pieces of quick match were threaded through the holes in the cup (precisely how is not clear). The upper surface of the composition was disturbed with a pricker, and the ends of the match were driven into it with a drift and mallet and a little mealed powder. A third piece of match was threaded under one of the other pieces on that side of the fuze in which the wood was thickest. The cup was then filled with dampened mealed powder. After it had dried, a hole 1/8 inch in diameter and 0.7 inch deep was drilled into the fuze composition. The level of the bottom of this hole, which marked the zero point of the composition, was marked on the outside of the fuze. The third piece of match was then coiled round the inside of the cup.

Parallel to, and 0.2 inch from the side of the fuze where the wood was the thickest, two powder channels, 0.125 inch in diameter, were drilled from the bottom almost to the top. Opposite and breaking into them, two rows of 10 holes of the same diameter as the channels were drilled. The two bottom holes were drilled through into the composition. These were 0.2 inch apart, centre to centre, the top hole of one row 0.2 inch below the zero point, the top hole of the other row 0.3 inch below. With the exception of the two bottom holes, they were filled with shell F.G. (fine grain) powder pressed down and covered with finely ground clay, similarly pressed. (Originally putty was used.) Wires of the diameter of the powder channels were inserted therein to provide a backing for the clay and putty. These were taken out and shell F.G. powder was poured, not pressed, into the powder channels. A piece of quick match was threaded into each of the bottom holes to support the channels of

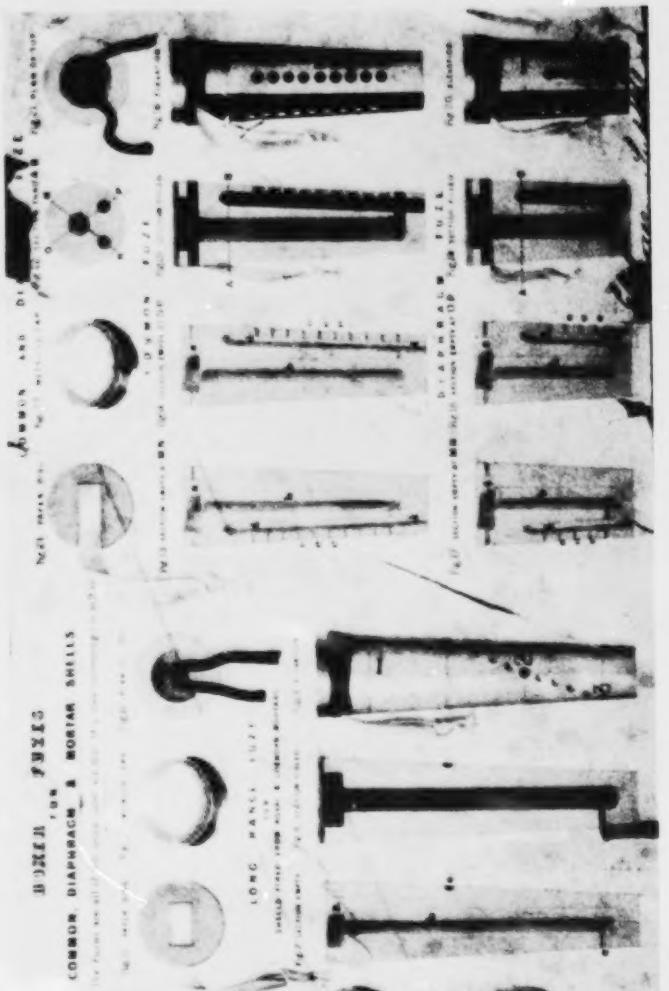

BOXER FUZES
FOR
COMMON, DIAPHRAGM & MORTAR SHELLS
LONG RANGE FUZE
COMMON FUZE
DIAPHRAGM FUZE
MORTAR SHELLS

Figure 223. Boxer Fuzes for Common, Diaphragm & Mortar Shells. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate ?, circa 1860)

powder, and their ends were closed with pieces of quick match pressed down and secured with shellac putty.

A pasteboard disc (made of two sheets of rocket paper and a sheet of 100 lb. brown wrapping paper as topping pasted together), to which a tape loop was attached, was placed over the top of the fuze. A tin cup (0.016 inch thickness of tin), its inside coated with an anti-corrosive, was put over the pasteboard disc, and its sides were pinched in to secure it. A strip of "white fine" paper was pasted over the side holes and end of the fuze. Finally, a disc of this paper was pasted over the end of the fuze.

Except for the top of the cup, the fuze was coated with drab-white varnish, and a strip of black varnish, thickened to exclude moisture, was put over the even-numbered row of side holes, the end of the fuze, and the junction of the cap and body. (These varnishes were made with spirit and not with oil, because spirit dried more quickly, and oil might have affected the fuze composition if it penetrated to it.) Except for the one at the bottom of each row, the side holes were dotted, those on the black ground in yellow, those on the drab ground in black. The tenths of inches were stamped in vermilion opposite the appropriate holes, except the bottom hole of each row. In 1864 the Ordnance decided to stamp near the top in vermilion the numeral of pattern, the number of thousand, and lower down, the month and year of issue.

To prepare the fuze for action, the gunner using a hook borer bored out the appropriate hole (1/10 inch for each 1/2 second of flight) (Fig. 224). He then set it home in the shell, using a mallet and setter for the larger shells or by striking against a wheel for the smaller. Only after the shell was in the bore of the piece did he give the tape a sharp pull to uncap the fuze.

The flash of the explosion from the discharge of the gun ignited the fuze composition, which burned down to the side hole that had been bored out. If the hole passed directly into the shell, the flame went directly to the bursting charge. If the hole came up against the side of the shell, the flame burned along the powder channel to reach the bursting charge. If the fuze was unbored or improperly bored, it would ignite the bursting charge after 10 seconds, since the 2-inch hole was bored through to the composition.[20]

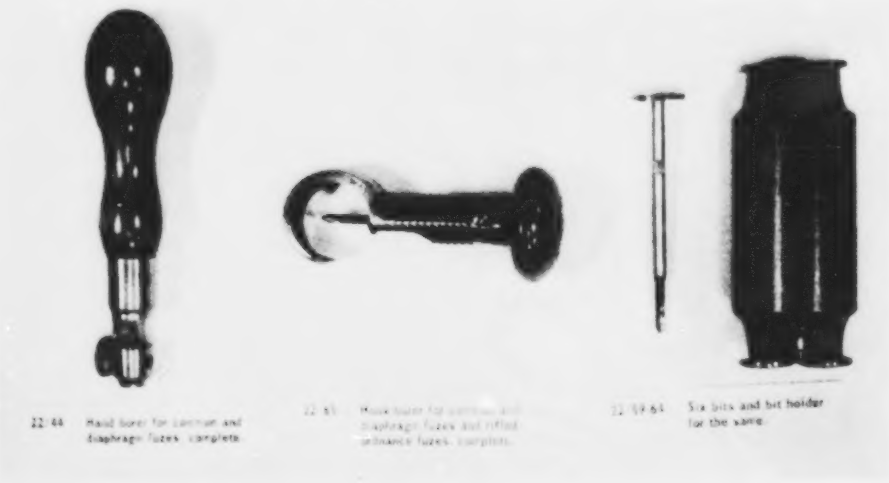

22/44 Hand borer for common and diaphragm fuzes, complete.
22/65 Hook borer for common and diaphragm fuzes and rifled ordnance fuzes, complete.
22/59-64 Six bits and bit holder for the same.

Figure 224. Fuze Borers and Bits and Holder. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda XXII/44, 59-65.)

Boxer's Diaphragm Shrapnel Fuze

The diaphragm shrapnel fuze was identical to the common fuze, with two exceptions (Fig. 223). Firstly, it was shorter with only 1 inch of fuze composition, and consequently, the powder channels were drilled with five holes each, rather than 10. The upper of the two bored-out bottom holes was marked 0 (for 10). Secondly, the powder channels were connected by a groove on the end of the fuze which was laid with quick match. Thus both channels were exploded simultaneously, the greater flash thereby secured making the ignition of the bursting charge more certain.[21]

There was, in addition, a fuze which could be used only with improved Shrapnel. It was identical to the diaphragm shrapnel fuze except that it was made on the "small cone" principle, being straighter and smaller in diameter with a pitch of cone of 0.065 inch per inch. It was distinguised by the top of its cap being painted red.[22]

Large Mortar Fuze

Designed to fit shells for 13-, 10-, and 8-inch mortars, this fuze was longer than the common fuze, taking 6 inches of composition (Fig. 223). It was shaped similarly, but although the pitch of the cone was the same, the frustum was of necessity larger and longer. There were no powder channels. The bore for the composition was drilled in the axis of the fuze, its diameter slightly larger than that of the common fuze, its length sufficient to hold 6 inches of composition. There was only one row of side holes, located spirally around the fuze; the top hole was 2 inches below zero, the bottom hole 6 inches. Except for the bottom hole, which was bored through to the composition, although not filled with quick match nor closed in any way, the other holes were not drilled out, but were only indentations, 0.1 inch deep, to indicate where the fuze could be bored. A ring was cut round the fuze at zero, to indicate the depth to which it penetrated into the 13- and 10-inch shells; another ring was cut 0.9 inch below this, marking the depth of penetration into the 8-inch shell that had a smaller fuze hole. Rings were cut at each inch from 2 to 6 and each was stamped in red accordingly; the intervening side holes were not numbered, but only stamped in red. The fuze was painted drab-white, except for a black ring round the junction of the cap and the body.

The large mortar fuze was quick matched more simply than the common fuze. The 6 inches of match was doubled, its ends set down into the composition, and then coiled round the inside of the cup, since there were no holes drilled through the sides of the cup. In other respects this fuze was similar to the common fuze.

The fuze was prepared for use in the same way as the common fuze, except that a brace and bit, rather than a hook-borer, was used to drill the hole (Fig. 225). It could not be prepared for flights shorter than 10 seconds (that is, 2 inches of composition), nor more accurately than within a second (that is, 0.2 inch between holes).[23]

Small Mortar Fuze

This fuze was to be used with 24-pounder and 12-pounder common shells when they were fired from 5-1/2-inch and 4-2/5-inch mortars at ranges beyond which the common fuze was effective, that is, beyond 10 seconds of flight (Fig. 223). It was the same shape as the large mortar fuze, but being a smaller frustum of the same cone, it contained only 3 inches of composition. The bore for the composition was the same size as that for the common fuze. The position of the side holes wound spirally around the fuze, and they were marked similarly to the large fuze, from 1 to 3 inches. In other respects its construction was identical to the large mortar fuze, and its burning, preparation, and action was similar.[24]

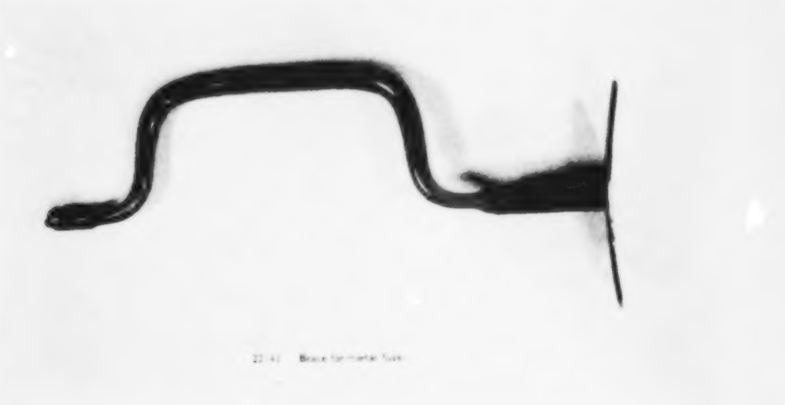


Figure 225. Brace for Drilling Mortar Fuze. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXII/43.)

Metal Fuzes

Between 1829 and 1832, when shells and shell guns were being introduced into the Royal Navy, gun-metal screw time fuzes, recommended by William Millar, were adopted for insertion into 10-inch, 8-inch, and 32-pounder naval shells.[25] It was argued at the time that metal screw fuzes were preferable to wood for naval use for a number of reasons:

1) a metal fuze made the storage of filled and fuzed shells less dangerous;
2) it provided a better barrier to damp reaching the bursting charge than a wooden fuze;
3) it was less likely to deteriorate from the effects of damp or climate, or to be damaged by accident;
4) it was less likely to be broken or knocked out when striking a solid object;
5) the explosive effect was greater with a fuze that screws.[26]

Until about 1850 there were four different sorts of these fuzes: a 3-inch and a 4-inch, each driven with mealed powder, which burned 7.5 and 10 seconds respectively; and a 4-1/2 inch and a 5-inch, each driven with fuze composition, which burned 22.5 and 25 seconds respectively.[27] Detailed specifications are lacking, but one note book contained a short description:

> The 10 & 8 Inch and 32 Po . Naval Shells are fitted with Metal Fuzes, they are driven in the same manner as other

> fuzes, screwed into a Metal Socket while driving, they are Quick Matched, and primed with meal powder, all confined within the cup, they have a Metal cap with a wire spiral spring, a circle of Buff placed on top of the spring, a circle of parchment is placed between the Fuze and cap to prevent friction, the cap is screwed on turning it to the right, a larger washer is greased and placed under the shoulder of the Fuze, the worm of the Fuze is also greased the Fuze is screwed into the shell turning it to the Left.[28]

Initially the fuze hole of the shell was formed into a female screw to take the fuze, but it was found that due to rust and increased friction, "Accidents have... happened with them, ignition having occurred in fixing them."[29] Consequently, by 1843 gun metal bouches were fitted into the fuze holes of naval shells to reduce the danger.[30]

In the 1850s these four types seem to have been reduced to three, but the sources are rather confusing. The Aide-Mémoire, in 1853, noted three metal fuzes: a 3-inch, driven with mealed powder, which burned seven seconds, and a 4-inch and a short range fuze, both driven with fuze composition, which burned 20 seconds and 2 seconds respectively. A 3-inch fuze driven with mealed powder should burn 7.5 seconds (2.5 seconds per inch); the length of the composition in the short range fuze would be only 0.4 inch long, a very short fuze indeed (composition burned at a rate of 0.2 inch per second).[31] Later sources in the decade described a 4-inch fuze, driven with fuze composition which burned 29 seconds, and a 3-inch and a 1.25-inch fuze, driven with mealed powder, which burned 7.5 and 2 seconds respectively. A mealed powder fuze 1.25 inches long should burn for 3.125 seconds, not 2 seconds.[32] It is difficult to arrive at any conclusions, except that, probably, changes were made in the metal fuzes during the 1850s, before Boxer's metal fuzes were adopted.

Boxer's Metal Time Screw Fuzes

Boxer turned his attention to metal fuzes late in the 1850s when he developed 20-second and 7-1/2-second metal time screw fuzes (Fig. 226). The former came into general use early in 1857 and the latter a little more than a year later. Although the principle of design of these fuzes remained unchanged, they were smaller in diameter than the later model, and the thread of the body was left handed and that of the neck, to take the cap, right handed. The shoulder above the thread, which rested upon the shell's surface when the fuze was screwed in, was square. In September 1858, in order to meet naval specifications, the fuze was ordered modified so that it could fit into the Moorsom fuze bush for naval shells (for Moorsom fuze see below). Consequently its diameter was increased, and the body thread became right handed and the neck thread left handed. At the same time the shoulder became round. This pattern was finally approved on 9 September 1859.[33]

20-Second Metal Time Fuze

This fuze, made of gun metal, was 5 inches long (Fig. 226). Its lower section, which protruded into the shell, was conical; but the screw part, immediately above, was cylindrical, cut with a thread pitched at 16-1/2 to the inch. The shoulder was a

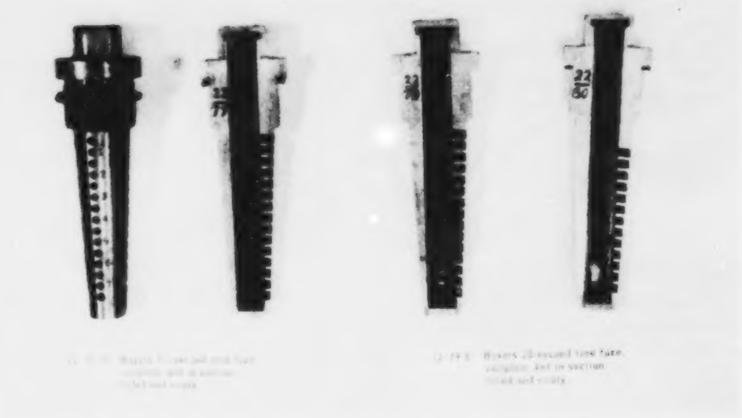


Figure 226. Boxer's 7-1/2- and 20-second Metal Time Fuzes. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXII/76-77, 79-80.)

plain cylinder drilled with four equidistant holes on its upper surface into which a special wrench fitted to screw the fuze in and out of the shell. A cylindrical neck, threaded to the left but pitched the same as the body thread, onto which a metal cap fitted, completed the fuze. This cap was not removed until the shell was in the bore.

A composition channel, 1/2 inch in diameter, was bored down the axis of the fuze to within about 0.2 inch of the bottom. It was tapped with a fine thread, and a rolled paper cylinder, one end stopped with a cardboard disk and its exterior smeared with shellac as a protection against damp, was inserted therein. Fuze composition was pressed or driven into the bore, where the paper lining prevented contact between it and the metal (fuze composition and metal had a deletereous effect on each other if they were touching). The fuze was matched and primed similarly to the mortar fuze.

Two rows of holes, each hole 0.2 inch from its neighbour, were drilled into the composition channel. These holes, with the exception of the last, were closed with pressed ground clay and dotted white. The top hole of one row was 1.5 inches below the zero point, the other 1.6 inches below. The bottom hole, at the 4-inch mark, was drilled through the paper lining into the composition to ensure the action of the fuze if it was improperly bored or not bored at all. It was made somewhat larger than the others, and after 1865, it was filled with a perforated powder pellet and closed with a piece of fine paper and shellac varnish to exclude moisture. Since all holes fell within the shell, powder channels were unnecessary.

A cylindrical gun metal cap, slightly squared to allow a key to grip it properly for removal, screwed onto the neck to close the fuze. A lead washer was inserted between it and the shoulder to ensure a moisture proof seal. Similarly, a leather collar was glued underneath the shoulder to exclude damp from the shell after the fuze had been screwed home.

Instead of being marked with the length of composition, this fuze had stamped on it opposite alternate holes the time of burning in seconds and half-seconds — thus 8, 10, 12, etc. on the even row and 8-1/2, 10-1/2, 12-1/2 on the odd row. Also, the date of manufacture was stamped on the bottom, and the numeral of pattern and number of thousand on the side of the shoulder. The fuze was completely lacquered to preserve it from corrosion.

To prepare the fuze for any time of flight between 7-1/2 and 20 seconds it was necessary to bore out the appropriate hole, through the clay and paper liner, with a brace and short bit or a hook borer. The fuze was screwed into the shell, and the metal cap was removed, but only when the shell was in the bore of the piece.[34]

7-1/2-Second Metal Time Fuze

This fuze was similar to the 20-second fuze in appearance, construction, and dimensions, but it was adapted for shorter times of flight and could be adjusted to quarter-seconds (Fig. 226). It was driven with 3 inches of pit mealed powder, which burned at twice the rate of fuze composition, that is, 1 inch in 2-1/2 seconds. As in the 20-second fuze, the red-dotted side holes were arranged in two rows, the holes 0.2 inch apart, but there were more holes, 15 in the even-numered and 14 in the odd-numbered row. The top holes of each row which were 0.2 inch and 0.3 inch from the zero point, were not numbered, but the alternate holes thereafter were stamped — 1, 2, 3, etc. in the even row and 1-1/4, 2-1/4, 3-1/4, etc. in the odd row.

Although the 7-1/2-second fuze was very similar to the 20-second fuze, it had certain distinguishing marks:

1) a groove cut around the top of the cup, painted red;
2) the letter M.P. (for mealed powder) stamped on top of the shoulder;
3) the side holes dotted red;
4) the different readings on the side holes.

The preparation of the fuze for use was the same as the 20-second fuze.[35]

Percussion and Concussion Fuzes

These fuzes were similar in that they depended upon the impact of the shell against the target for their action. The distinction between them has been confused and "... altogether arbitrary, and the application of the terms depended upon the sense in which the inventor of any particular fuze chose to apply them."[36] A common distinction was that a percussion fuze contained a detonating chemical composition exploded by the shock of impact, while a concussion fuze did not. In 1863 the Ordnance adopted the following definition:

> A percussion fuze is one which is prepared to act by the shock of discharge, but put in action by the second shock on striking the object. A concussion fuze is one which is put in action by the shock of discharge, but the effect of that action is restrained until it strikes the object."[37]

The similarity between the two kinds of fuzes was more important than the semantical difference.

Although there is evidence that such fuzes were used as early as the seventeenth century, with ineffectual results, they were not adopted in the British service until 1846. In 1845 a mixed military and naval committee tested five different percussion or concussion fuzes, but none were deemed sufficiently efficient to be recommended for service. The next year Quartermaster Freeburn, R.A., designed a wooden concussion fuze for 32-pounder shells and upwards which was approved for the land service on 12 October 1846.[38]

The Freeburn Fuze

The Freeburn Fuze, looking much like an old mortar fuze, was made of beechwood, conical in shape with an enlarged head, and about 6 inches long. The composition channel, the upper end of which was enlarged into a cup, was drilled down the axis of the fuze to within a short distance of its bottom. Three rectangular perforations, equidistant from each other, were cut into the fuze penetrating to the composition channel in a plane about 2-1/4 inches from the top, that is, far enough down that they opened within the shell when the fuze was fixed. Three gun-metal wedges were placed in the holes. On the inside they were supported by the fuze composition, which was driven half way up them; on the outside they were held in place by pieces of wood secured with copper wire. A strip of paper, painted white, about 1 inch wide, was pasted around the fuze to cover the holes. A long piece of quick match was set into the top of the composition and its end coiled around the interior of the cup, which was then primed with a paste of mealed powder. The fuze was capped with paper and a piece of painted canvas was tied on. The bottom of the composition was bored into from the side to ensure action if the concussion arrangement failed.

When the shell was fired, the composition, the top 1/2 inch of which was mealed powder, was ignited by the flash of discharge; as it burned away, it deprived the gun-metal wedges of their internal support. The shock of impact then jarred the wedges loose, leaving passages for the flame from the burning composition to pass into the shell and explode the charge. These fuzes were effective up to the length of time the composition continued to burn, from 12 to 13 seconds.

Since the Freeburn fuze was made of wood, it was not suitable for sea service. It shortly became obsolete in the land service when the Boxer system of fuzes was introduced in 1850. When the new fuze hole and cone was adoped in 1855, it was not altered, thus becoming unserviceable even though large stores of it continued to exist.[39]

Moorsom's Fuze

In 1850 and 1851 William Moorsom, R.N., developed a metal percussion fuze that met the needs of the navy (Fig. 227). Three models were tested; the last, "C" pattern, was approved on 16 July 1851. It remained officially in service in the Royal Navy until 2 May 1865 when the existing stores of it were ordered to be broken up, but practically it had become obsolete with the introduction of the Pettman fuze in 1862; thereafter it ceased to be manufactured and was only issued in reduced proportions to 32-pounder shells.[40]

This fuze was made of gun metal, consisting of a body generally cylindrical but tapering toward the end, and of a projecting head or shoulder. It was nearly 4 inches long and 1.2 inches in diameter below the head. It was threaded for about 1 inch below the head, pitched at 16-1/2 to the inch. Four holes (originally two) were drilled into the top of the head into which a special wrench fitted for inserting or removing the fuze (Fig. 228).

Three cylindrical detonating chambers were drilled into the fuze below the thread. Two, identical in layout and function, were drilled longitudinally, one above the other but at a right angle to each other. At the end of the chamber a small recess was drilled and then a smaller hole to the outside. It was closed with a screw plug in which the recess and hole opposite were duplicated. A small patch of detonating composition was put into each of the recesses. It was made up of equal quantities of sulphide of antimony and cholorate of potash made into a paste with varnish of shellac and methylated spirits. A cylindrical gun-metal hammer, with a nipple on each end, was suspended in the chamber by a fine copper wire (18 wire gauge) which passed through holes in the hammer and in the sides of the chamber to the outside of the fuze to which it was soldered.

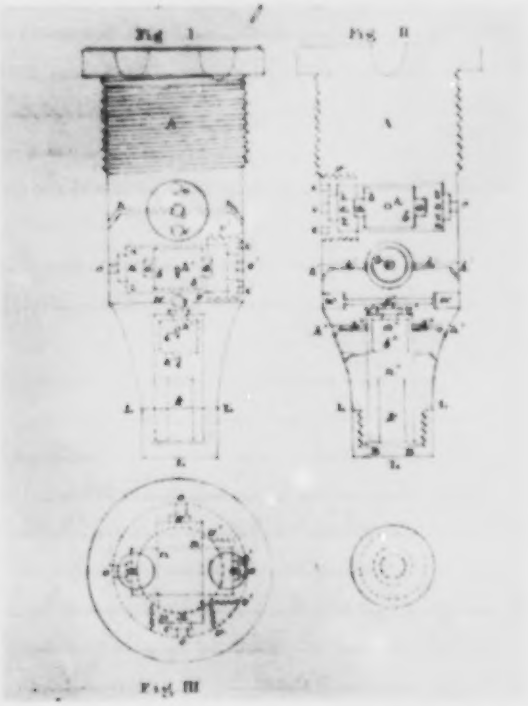


Figure 227. Moorsom Percusion Fuze. (The Royal Artillery Institution, Woolwich, U.K., Richardson, Long Course..., 1859.)

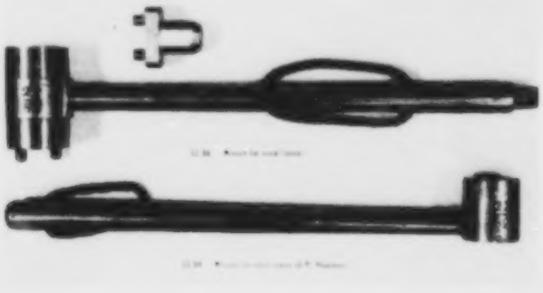


Figure 228. Wrenches for Naval Fuzes. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXII/88 and 89.)

The third chamber, also a cylinder, was drilled vertically into the bottom of the fuze. A recess, into which a patch of detonating composition was placed, was drilled into its upper end. The fire hole was drilled horizontally through the fuze connecting with the recess; its ends were enlarged to allow grains of powder of the shell's bursting charge to work in. A gun-metal hammer, with a nipple only on its upper end, was suspended below the composition by a fine copper wire (21 wire gauge) in the same way as in the upper chambers. In addition, as safety precautions to prevent premature detonation, a guard wire (26 wire gauge) was passed between the nipple and the composition, and a lead pillar was inserted into the bottom of the chamber and held in place by a screw cap fitted onto the end of the fuze. Finally a piece of tracing paper was secured by varnish shellac over the four holes of the horizontal chambers, and a similar piece varnished over the lower part of the fuze.

When the gun was fired, the shock of discharge sheered off the wires suspending the hammers, thus freeing them to move about in their chambers. When the shell struck its target, one or more of the hammers would be propelled into the detonating composition, setting it off, the flame passing through the fire holes to the bursting charge, thereby exploding the shell.[41]

Pettman's Fuzes

With the adoption of the smaller fuze hole in 1855 and the consequent obsolescence of the Freeburn fuze, the land service was without a percussion or a concussion fuze. In January 1860 Mr. Pettman, a foreman of the Royal Laboratory, Woolwich, put forward a new design of percussion fuze. It relied on a small metal ball coated with detonating composition being set free inside the hollow metal fuze body by the shock of discharge and then being detonated against the sides of the chamber by the shock of impact of the shell against its target. Both the land and naval service tested the fuze and while finding it generally satisfactory, made various modifications to the design. Pettman's land service fuze was adopted on 30 October 1861 and his naval service fuze on 2 August of the next year. Later, Pettman proposed modification of the naval service fuze to use it in rifled as well as smooth-bore shells. Known as the general service fuze, it was introduced on 19 May 1866 for immediate use with certain rifled shells and in the future to supersede the naval service fuze for naval smooth-bore shells.[42]

Pettman's Land Service Percussion Fuze

This fuze consisted of seven parts:

- Body
- Top plug
- Bottom plug
- Lead cup
- Cone plug
- Detonating ball
- Steady plug

It was made of gun metal, its body hollow and slightly conical, conforming to the common fuze – hole taper of 1 inch in 9.375 inches. Its lower end was slightly rounded; its upper end was a plain projecting head or shoulder which rested on the surface of the shell when the fuze was inserted in it. Four equidistant holes were cut into the upper surface of the head into which a special wrench fitted to insert or remove the fuze. It was cut with a right-hand thread to fit the fuze hole of the common shell, pitched at 14 to the inch. The top and bottom of the hollow interior were tapped with a right-handed thread, pitched at 14 to the inch, to receive the top and bottom plugs. Otherwise the interior was a plain cylinder, except for a slight concavity just above the bottom plug.

The top plug was a gun-metal screw that closed the top of the fuze. A square key-hole was cut into its upper surface to take a key by which it was inserted or removed from the fuze.

The bottom plug, another gun-metal screw, served the same purpose in the bottom of the fuze. It had a small projecting stud on its upper surface and a small cut for a screw driver on its lower. A small passage, which served as the fire hole to pass the flame to the bursting charge, was drilled along its vertical axis. Another hole was drilled horizontally through the fire channel and threaded with a piece of quick match to prevent grains of powder from the bursting charge working their way in and choking the fuze.

The lead cup was a hollow cylinder of pure lead, its bottom completely open but its top pierced by a small hole. It rested on the bottom plug, surrounding but not touching the stud, its lower sides adopting to the slight concavity of the lower interior of the fuze.

The cone plug, which was made of a harder alloy (copper, 87.5% and tin, 12.5%) than the rest of the fuze, was a plain cylinder, its slightly bevelled top edge fitted exactly the interior of the fuze. A stud projected from its underside. A fire hole was drilled through the stud along the vertical axis of the plug. It rested on the lead cup, the stud entering into its top hole.

The detonating ball was a solid sphere of the harder alloy, its surface roughened and a groove cut round its horizontal circumference. At the extremes of its vertical axis there were two projections, the lower one conical and the upper one cylindrical, with a small shoulder round its base. A small groove was cut round the neck of each projection.

The detonating composition was composed of:

Cholarate of potash	6 oz.
Sulphide of antimony	6 oz.
Sublimed sulphur	1/2 oz.
Mealed powder, L.G.	1/2 oz.

made into a paste with varnish of shellac and methylated spirits. It was plastered over the surface of the ball up to but not in the grooves at the necks of the projections. In order to safeguard the composition from premature detonation, the ball was covered with fine sheep's gut tied on with silk cord and varnished. When this proved insufficient, it was additionally covered with Sarsenet silk, similarly secured and varnished. The ball, with its conical projection inserted into the fire hole, rested on top of the cone plug.

The steady plug was a cylinder of the harder alloy that fitted exactly the interior of the fuze. A hole was drilled through it along its vertical axis which allowed it to fit over the upper projection of the detonating ball. When the steady plug had been inserted, the top plug was screwed in closing up the fuze.

When the fuze had been assembled, the key-hole in the top and the slot in the bottom were filled with shellac putty, and discs of fine tracing paper were varnished onto the top and bottom to exclude moisture. (This paper would eventually be broken at the wrench holes when the fuze was screwed into the shell.) A leather collar was secured by shellac varnish underneath the shoulder to exclude damp from the shell after the fuze been inserted.

The pattern numeral and the number of thousand of the fuze was stamped on top of each fuze between the wrench holes, and, after 1864, also the year and month of issue. The entire exterior of the fuze was then lacquered to prevent corrosion.

The fuze needed no preparation before it was screwed into the shell. When the gun was fired, the lead cup was crushed, partly by its own inertia and partly by the weight of the cone plug, detonating ball, and steady plug resting on it. The crushing of the cup created an area for the movement of the detonating ball within the fuze. At the same time, by expanding around the studs on the bottom and cone plugs, the lead cup had rivetted itself and the cone plug to the bottom plug. The rotation of the shell during flight disengaged the detonating ball and the steady plug. When the shell struck an object, the ball was thrown violently against some part of the interior of the fuze, detonating the composition, the flash passing through the fire holes in the cone and bottom plugs into the bursting charge to explode the shell.[43]

Pettman's Sea Service Percussion Fuze

The principle of action of Pettman's sea service fuze was the same as that of the land service, but some of the details of its construction were different. It was larger in diameter than the land service fuze, and threaded to fit the fuze holes of naval shells, that is the Moorsom gauge, right-handed, but pitched 16-1/2 to the inch. Also, the thread only extended 3/4 inch below the head or shoulder. In order that the naval wrench could be used the holes in the upper surface of the head were further apart. There was no bottom plug, only a fire hole that was closed with a disc of cardboard over which a disc of fine tracing paper was varnished.

The detonating ball was the same size and shape as the land service fuze, and it was covered with the same detonating composition. In addition, it was enclosed by two hemispherical cups of thin sheet copper (0.008 inch thick), joined round their horizontal circumference by a strip of tissue paper varnished on. Then, the ball was covered with gut, silk, and varnish in the usual manner. The copper cups regulated the sensitivity of the fuze, preventing its detonation when ricocheting off the water, but still allowing its detonation when striking the side of a ship. The interior of the fuze was enlarged, not only to equalize the force of the detonating ball striking in every direction, but also to control its sensitivity.

The cone plug was also constructed differently from that in the land service fuze. Its stud was prolonged downward as a hollow table which was filled with mealed powder and pierced like the composition in a tube. The lower end was closed by a cardboard disc. The plug sat on top of the lead cup, as in the land service fuze, but the tube extended through it into the fire hole in the bottom of the fuze. Since there was no stud projecting up from the bottom, the lower part of the fuze interior was undercut or hollowed out. Thus, when the lead cup was crushed, it expanded outwards into the hollow where it was securely held, while its upper part contracted around the stud of the cone plug to prevent its farther movement. The lead cup was made of such a size and weight that the fuze would act with a very reduced charge.

The sea service fuze was marked with the pattern numeral, the number of thousand, and, after 1864, the month and year of issue. It was then lacquered all over.

This fuze acted similarly to the land service fuze, except when the lead cup was crushed, the tube of the cone plug was forced beyond the fuze bottom, thereby forcing out the cardboard disc which closed the fire hole. When the ball detonated on impact, the flame flashed through the tube into the bursting charge to explode the shell.[44]

Pettman's General Service Percussion Fuze

Because there was no lateral movement or rotation in breech-loading rifle shells, it could not be depended upon that the steady plug of Pettman's fuze would separate from the detonating ball, a failure which could result in a blind shell. Pettman's general service fuze was developed to solve this problem, and eventually it entirely superseded the sea service fuze (Fig. 229).

Externally the fuze was conical, lacked a projecting shoulder, and had a right handed thread over its whole length, pitched at 14 to the inch. Its cone, increasing 1 in 9.375 inches, was gauged to fit the general service fuze hole.

length	1.95 in.
diam., top	1.213 in.
bottom	1.006 in.

Two slots cut in its top served as key holes for screwing the fuze into the shell.

Although the interior arrangements were similar to the sea service fuze, certain modifications had been made to ensure detonation. The bottom of the top plug and the top of the steady plug were cupped out in the centre to hold a plain metal ball (70 parts copper, 30 parts zinc), which kept the two plugs slightly apart. A circular groove cut into the top of the steady plug was pressed full of dry detonating composition and covered with a thin copper washer (0.008 in. thick) to serve the same purpose as the copper cups round the detonating ball of the sea service fuze. Two conical fire holes were drilled vertically from the composition grove through the plug.

The cone plug was also modified. Its upper surface was no longer conical but flat. As well as the central fire hole through the elongated stud or tube on its bottom, two inclined fire holes were also drilled through it. A suspending wire (0.087 inches thick), which passed through the lower part of the tube and rested on the fuze bottom, supported the interior parts. The lead cup remained, but it only served to rivet down the cone plug after discharge.

The general service fuze acted in much the same way as the naval service fuze, except that the shock of discharge had to shear the suspending wire. If the detonating ball did not become disengaged from the steady plug in a breech-loading rifle shell, the fuze was still detonated on impact by the plain ball striking the composition in the groove on the top of the steady plug. The flash passed through the fire holes to the detonating ball and thence through the cone plug to the bursting charge, thereby exploding the shell.[45]

Later Wooden Time Fuzes

The 9-second Fuze for Muzzle-Loading Ordnance (wood)

On 26 June 1866 this fuze was approved for use with certain muzzle-loading rifle shells, but it was intended that eventually it would replace the 7-1/2-second metal time fuze for naval spherical shells as well (Fig. 230). It could be used in all muzzle-loading shells which had the general service fuze hole or adapter. Like the common fuze, it was drilled for a composition channel and two powder channels, each of the latter with a row of side holes, but it was about an inch longer and somewhat thicker to fit the general service fuze hole.

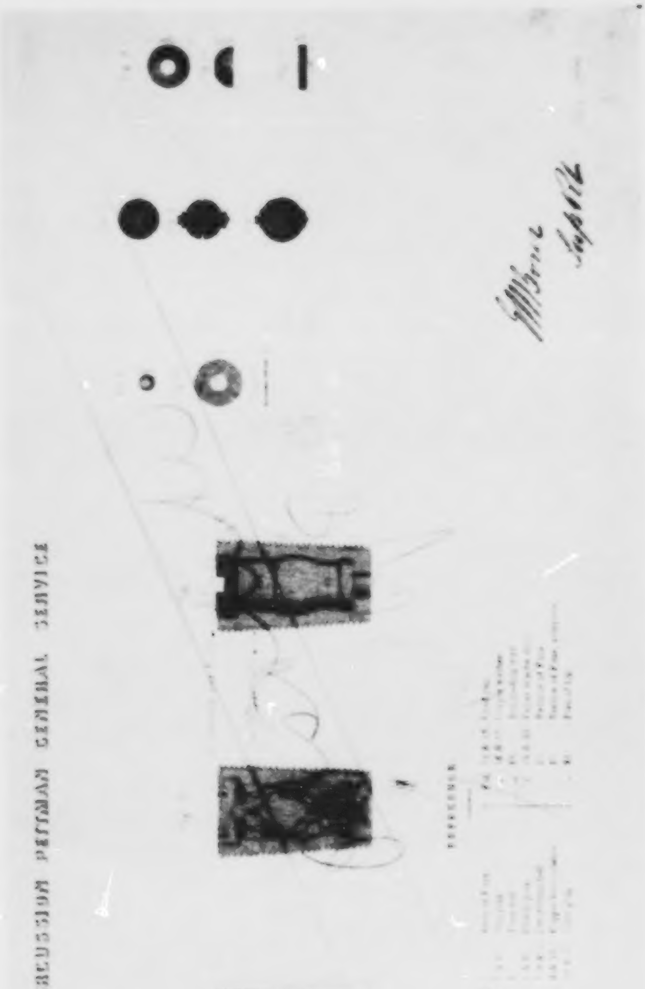

FUZE PERCUSSION PETTMAN GENERAL SERVICE
REFERENCE

Figure 229. Fuze Percussion Pettman General Service. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate 44, July 1866.)

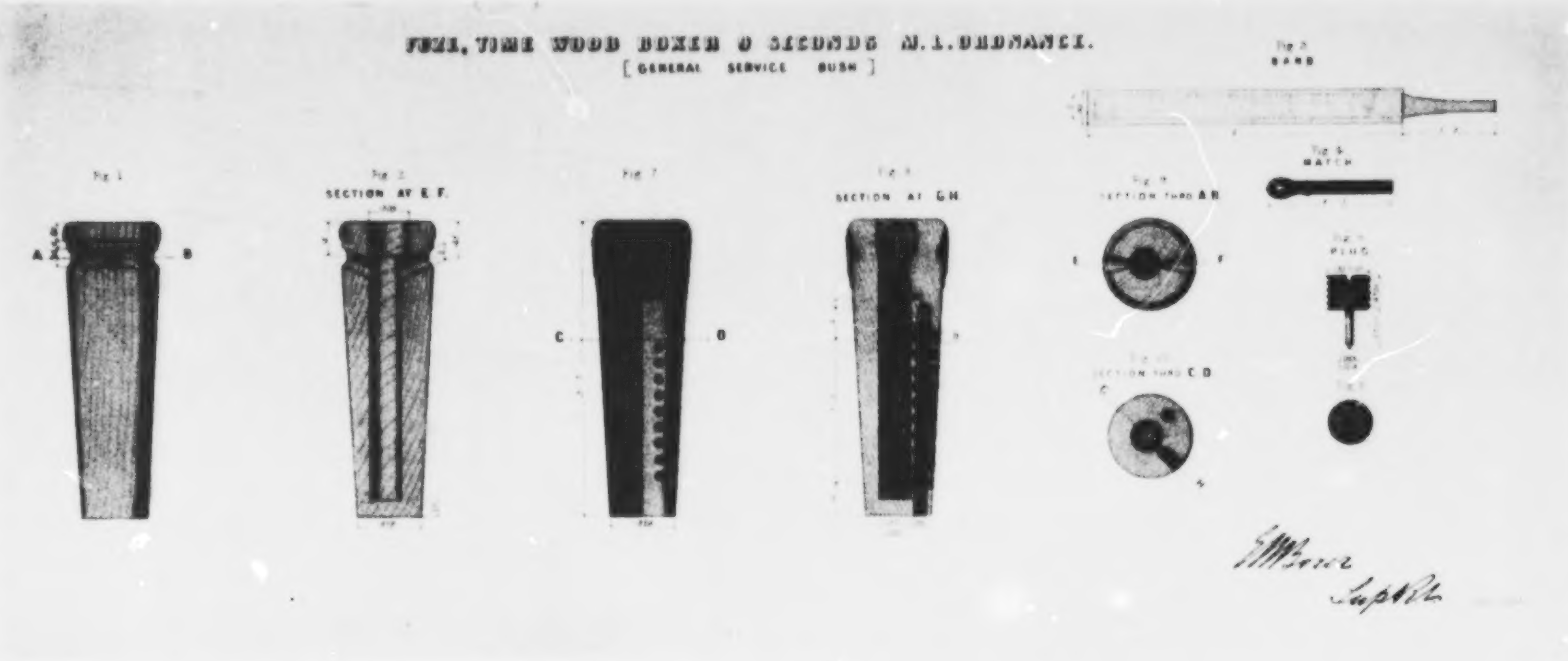

FUZE, TIME WOOD BOXER 9 SECONDS M.L. ORDNANCE.
[GENERAL SERVICE BUSH]
SECTION AT E.F.
SECTION AT G.H.
SECTION THRO A.B.
SECTION THRO C.D.
BAND
MATCH
PLUG
A
B
C
D
E
F
E.M. Boxer
Supt R.L.

Figure 230. Fuze, Time Wood Boxer 9 Seconds M.L. Ordnance. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate 45, July 1866.)

Unlike the common fuze, the 9-second fuze was primed differently. The upper end of the composition channel was closed by a gun-metal plug screwed in flush with the top of the fuze. It prevented the extinction of the fuze if it hit the target end on and the great acceleration of the burning of the composition caused by the rapid passage of air during flight around the fuze fixed in the apex of a rifle shell. Two holes were drilled through the side of the fuze entering the composition channel just below the plug, and a groove was cut round the head of the fuze joining them. A piece of quick match was threaded through these holes and looped round a copper pin that projected from the plug. The ends of the match were laid in the groove round the head of the fuze, and they were covered, first by a strip of thin sheet copper, and then by a tape band, one end of the copper being left exposed. The band and upper end of the fuze were painted black, and its top was covered with shellac varnish.

The composition channel was lined with a tube of white wrapping paper coated with shellac. This prevented a space being formed between the composition and the wood if the wood shrank, in which case the composition would explode rather than burn regularly. The composition was the same as that in the common fuze, but mealed pit powder was used above the top side hole. The side holes of the powder channels were plugged with rifle powder only, no ground clay being used. Like the arrangement of the diaphragm fuze, the bottoms of the powder channels were connected by a piece of quick match to ensure a greater flash.

The fuze was prepared in the same way as the common fuze by boring out the appropriate side hole into the composition. It was then pressed and screwed into the shell by hand, a mallet and setter not being necessary. Only when the shell was in the bore of the gun was the copper band and tape taken off, exposing the quick match. The match, ignited by the flame of discharge, ignited the composition that burned down to the bored-out side-hole through which the fire passed to the bursting charge to explode the shell.[46]

The 20-second Fuze for Muzzle-Loading Ordnance (wood)

In some respects this fuze was similar to the 9-second fuze and in others to a fuze for a mortar shell (Fig. 231). Like the former, the composition channel was lined with a paper cylinder and its upper end stopped by a metal plug; its head was grooved and drilled for quick match and the match was held in place by copper and tape bands. Like the latter, it had only a composition channel and only one row of side holes arranged spirally around the body. The composition was 4 inches long with 0.1 inch of mealed powder on top into which a small hole was bored to facilitate ignition. A hole was drilled through the fuze immediately below the composition into which a pellet of mealed powder, pierced like a tube, was placed. The ends of the hole were closed with discs of thin paper secured with shellac varnish. The side holes were marked from 2 inches downwards, each hole numbered in tenths of inches.

The 20-second fuze could be used with any muzzle-loading shell, rifle or smooth-bore, which had the general service fuze hole or adapter, where a time of flight between 10 and 20 seconds was desired. Eventually, it was to supersede the metal 20-second fuze for naval spherical shells. The side hole was drilled out in the same way as the fuze for a mortar shell, and it was uncapped similarly to the 9-second fuze. Its action was the same as a mortar fuze, with addition of greater intensity of flash if the composition was allowed to burn to the powder pellet in the bottom of the channel.[47]

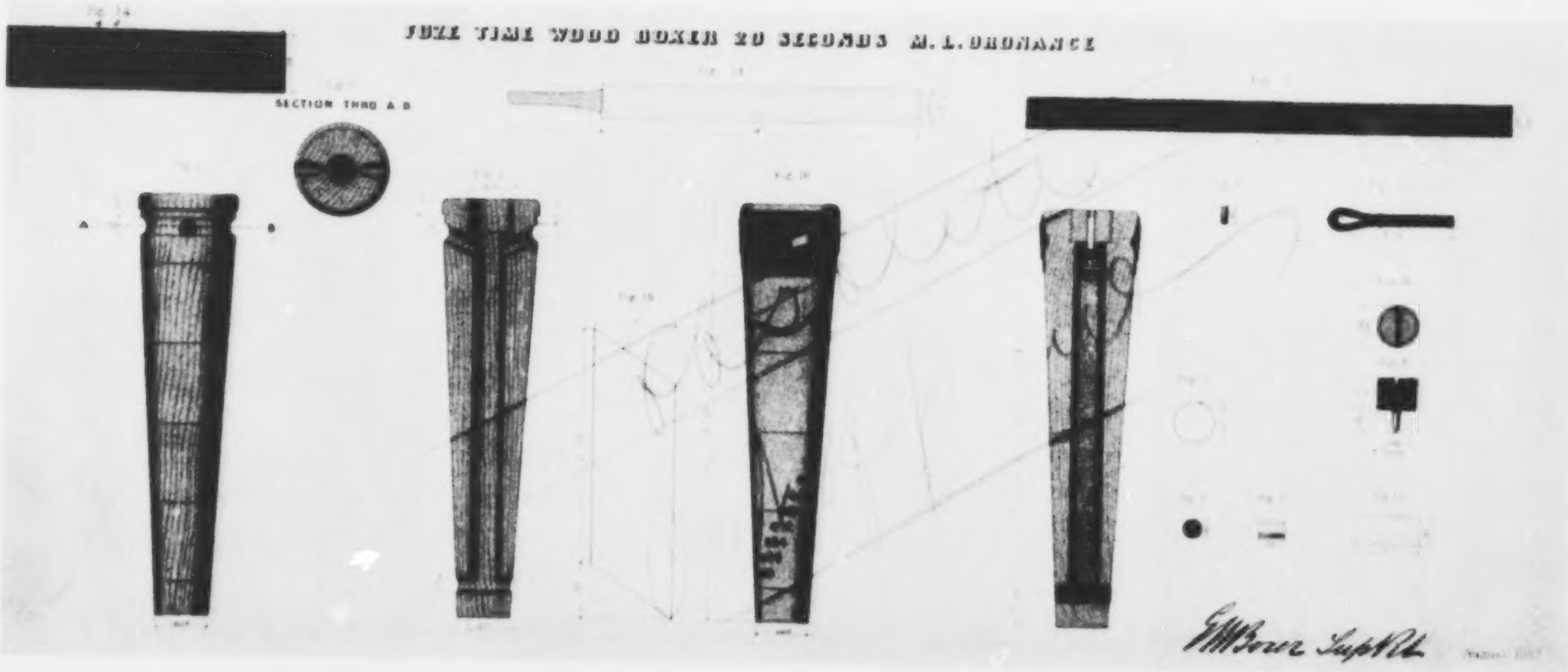

FUZE TIME WOOD BOXER 20 SECONDS M.L. ORDNANCE
SECTION THRO A B
A
B
G.W.Boxer Supt R.L.

Figure 231. Fuze Time Wood Boxer 20 Seconds M.L. Ordnance. (The Royal Artillery Institution, Woolwich, U.K., Royal Laboratory, Plate 51, August 1867.)

IGNITION

The ignition system was the method by which fire was transmitted to the propellant charge in the chamber of a piece of artillery. At the most primitive, the charge could be ignited by inserting a hot iron into the vent, a practice that could be most dangerous to the gunner. Later, a train of powder was poured down the vent and into the vent shell and set alight, perhaps at first by a hot iron, but then by slow match or portfire. To replace the trains of loose powder, tubes were devised that were inserted into the vents of artillery pieces from at least 1755 to the 1860s. Depending on their design, they could be fired by match or portfire, by flintwork, or by percussion lock. Finally in the 1850s a self-sufficient device, the friction tube, was invented.

Slow Match

Although slow match was usually made of hemp rope, loosely twisted, its preparation varied from time to time.[1] About 1750, it was "... Spun in Three Layers not too hard and then boild [sic] in Slacks & Lime & some Brimstone and a proper Proportion of Water."[2] In 1779, Smith gave a more detailed and somewhat different account:

> It is made of hempen tow, spun on the wheel like cord, but very slack; and is composed of three twists, which are afterwards again covered with tow, so that the twists do not appear: lastly it is boiled in lees of wine.[3]

In 1816, James repeated this description, but it is likely that by then slow match was being prepared otherwise.[4]

According to the sources consulted, from the 1820s to about 1850, a strong lye of wood ashes and lime was substituted for the lees of wine.[5] In the 1850s and 1860s the solution was said to be composed of saltpetre and lime water.[6] But in his authoritative study of smooth-bore ammunition published in 1867, Majendie maintained that according to the authorities at Chatham, where the match was then manufactured, slow match had been made by boiling it in a lye of wood ashes and water for more than 20 years. He also commented on the failure of all the sources published up till the time of his writing to have noticed the change and on their continuing to describe a solution of saltpetre and water, or saltpetre and lime water (8 oz. of saltpetre to 1 gal. of water).[7] Presumably Majendie, who was Assistant Superintendent of the Royal Laboratory at Woolwich, was correct; probably the other sources were also correct but out-of-date and their information needs to be pushed back 20 years or so.

The match that was soaked in saltpetre and lime water burned at the rate of 1 yard in three hours; that soaked in the lye of woodashes burned more slowly, 1 yard in eight hours.[8] It was made up of skeins of 35 yards weighing 7 pounds each or, if larger amounts were required, packed in bales of up to 1 hundredweight.[9] Early in its history it had been used to ignite the priming of guns and later to light the portfire, but it was rarely used after the adoption of friction tubes even though it was still issued to all artillery equipments in the 1860s.[10] It remained useful as a fuse to fire charges of powder if it was necessary for some time to elapse between the ignition of the match and the powder.[11]

Quick Match

Artillerists had used quick match for many centuries. From the early 1600s it was employed to fire guns when a piece of it, fed into the vent and ignited, acted as a weak tube.[12] The invention of tubes proper rendered this use obsolete, but quick match continued to be necessary for laboratory manufacture, particularly in the priming of carcasses and fuzes. Usually made from cotton wick or yarn, although worsted was also used, it was soaked in a solution of either saltpetre or gunpowder dissolved in water or spirits of wine (alcohol), then sprinkled with gunpowder, and dried. Its precise manner of manufacture varied until about 1760, however. For example, about 1750 Glegg gave three slightly different formulae:[13]

Cotton	4 lb.	?	?
Saltpetre	6 lb.	6 lb.	6 lb.
Gunpowder	–	6 lb.	–
Spirits of wine	4 qt.	6 qt.	–
Water	12 qt.	12 qt.	about 11 qt.

In the 1760s the ingredients, their proportions, and the method of manufacture (excepting the amount of water) were standarized and remained unchanged for almost a century.

Cotton wick	1 lb. 12 oz.
Saltpetre, pulverized	1 lb. 8 oz.
Powder, mealed	10 lb.
Spirits of wine	2 qt.
Water	1 1/2 to 4 qt.

The variation in the amount of water used might be accounted for by the length of time the solution was boiled. Small quantities of isinglass were said to have been added in the 1770s, but this may have been an error or, if true, an aberration. The saltpetre was put into a large copper pan with two handles, the wick coiled on top of the saltpetre, and each end of it tied to a handle. The water was added and the solution boiled (the time varied); then, the spirits of wine were added and the mixture was allowed to simmer for a short time. Next, the pan was removed to another room where some of the gunpowder was poured in and the wick was allowed to become well soaked. Then, the ends of the wick were untied and it was gently passed through the fingers into another pan. Some recipes say that more powder was added, others only that the remaining liquid from the first pan was poured over the wick. Once more it was allowed to soak for a short time, after which an end of the wick was tied to a reel and it was reeled out of the pan, again being passed gently through the fingers to shape it (Fig. 232). As each reel was filled, the wick was cut, and the reel was then placed on two battens on a table; the remaining powder was sifted over each side of it. After the wick had been allowed to dry (about 10 days in summer), it was cut into lengths, tied up in bundles, weighed, and ticketed for use.[14]

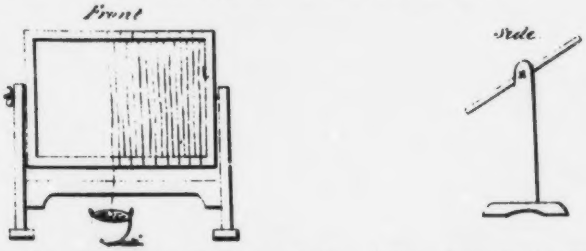


Figure 232. Reel for Winding Quickmatch. (The Royal Artillery Institution, Woolwich, U.K., "Artillery Implements...")

The number of threads of cotton making up the match, as well as the use to which each thickness was put, seems to have varied from time to time. About 1770 quick match was said to be made up of from one to four threads; in 1779 Smith in one place in his Dictionary wrote that it was composed of three threads and in another from one to six threads.[15] About 1800 quick match from two to eight threads was specified and their various uses set down:[16]

No. of threads	Uses
6 & 8	priming fire ships & fire barrels
4	priming 13,10, & 8-inch round iron carcasses, 10 & 8-inch oblong carcasses; 42,32, & 24-pounder round iron carcasses with 3 holes for guns & carronades; 13,10 and 8-inch fuzes & smoke balls
3 & 2	priming 5 1/2 & 4 2/5-inch fuzes; 18 & 12- pounder round carcasses with 3 holes; for cutting into lengths for firing mortars & howitzers; priming fuzes for land and sea service and grenades.

In the 1820s, Robert Swanston in his notebook listed the uses of quick match:[17]

> Quick match is a very necessary article and is used for priming of Fuzes Round and Oblong Carcasses Light Balls Smoke Balls Fire Balls and Fire Ships for Quickmatching the Cases and leading most kind of Fire works, and for Mortar Practice Experiments &c
>
> Quick Match of two threads for priming Hand Fuzes, 3 threads do. for 5 1/2 and 4 2/5-Inch Fuzes 4 threads for 8 Inch Spherical Fuzes 5 threads for 8 Inch Common Fuzes 6 threads for 10 and 13 Inch Fuzes

Some time in the 1850s the ingredients for making the match were changed slightly and the proportions thereof were varied, depending on the thickness of the match:

	4 thread	6 thread	10 thread
Cotton wick	1 lb. 10 oz.	2 lb. 2 oz.	2 lb. 7 oz.
Water, distilled	8 pints	9 pints	10 pints
Gum, Arabic	8 oz.	9 oz.	10 oz.
Powder, mealed cylinder	20 lb.	20 lb.	24 lb.

The method of preparation remained essentially the same as before, the wick being boiled in solution of gum arabic, mealed powder, and distilled water; the gum was added to cause the powder to adhere to the cotton. Only two-thirds of the powder was put into solution; the remainder was sifted over the match when it was put onto the reels in the manner previously described. The 4-thread match was the most commonly used. All burned at the rate of 1 yard in 13 seconds if unconfined.[18]

A worsted quick match was also manufactured, but it was discontinued for use when short tin and quill tubes were adopted for service in 1788.[19] The implication seems to be that it had been used to fill tubes rather than composition. The ingredients for it were:

Worsted	10 oz.
Spirits of wine	3 pints
Water	3 pints
Isinglass	1/2 pint
Mealed powder	10 lb.

It was prepared in much the same way as cotton quick match except that the water was not boiled, the worsted being allowed to soak in a cold solution.[20]

Portfire

The common portfire, used to ignite the charge of a piece of artillery, was a rolled paper tube closed at one end and driven with a composition of saltpetre, sulphur, and mealed powder. Its name derived from the French porte-feu which was originally used to denote a piece of quick match fed into the vent of a gun or mortar to act as a weak tube. Not until the end of the seventeenth or the beginning of the eighteenth century did it assume its modern meaning.[21] In 1710, a portfire was defined as:

> a composition of Meal, [sic] Powder, Sulphur and Salt-Peter drove into a case of Paper, but not very hard; 'tis about 9 or 10 inches long, and is used to fire Guns and Mortars instead of Match.[22]

Thereafter its dimensions or the precise manner of its manufacture may have varied somewhat, but this definition of a portfire would have been recognizable 150 years later.

The amounts of the three ingredients of the composition varied during the eighteenth century, and at times small quantities of antimony or linseed oil were said to be mixed in as well, but a mixture of the proportions of

saltpetre	6 lb.
sulphur	2 lb.
mealed powder	1 lb.

can be traced back to 1750.[23] By 1800 these were the only proportions noted, and they remained constant until about 1860, when the quantity of mealed powder was increased to 1-1/4 pounds.[24]

The dimensions of portfires varied only slightly between 1750 and 1860. In 1779, Smith wrote that a portfire was rarely longer than 21 inches, its length being usually 17 inches.[25] After 1800, it was commonly said to be 16 inches long, but 16-1/4 and 16-1/2 inches were also recorded.[26] There were also minor changes in the interior and exterior diameters; the earlier portfires seem to have been slightly smaller. For example, in 1766, the exterior diameter was said to be 6/10 inch and the interior 5/12 inch; about 1800, they were 0.64 and 0.43 inch respectively; in 1867, 0.675 and 0.45 inch respectively.[27] Such changes hardly seem significant.

The process of manufacturing portfires may be divided into four stages: mixing the composition; rolling the case; driving and priming; and packing.

The ingredients of the composition (saltpetre, sulphur, and mealed powder) were weighed out in their proper proportions onto a table, mixed by hand or with a wooden rubber, and passed through a hair sieve four times. Then the mixture was scooped into a wooden box and taken to the driving room.

The cases were made of paper, pasted and rolled with a rolling board on a former. Early sources referred to either 6-pounder or 9-pounder cartridge paper, a coarse, tough paper used presumably to make cartridges to hold the charge for a 6-pounder or 9-pounder gun. Later, what was called 60-pound paper (1 ream, or 480 (sometimes 500) sheets, weighed 60 pounds) was specified; how this differed (or, indeed, if it differed at all) from the cartridge paper is not known. About 1856, because of a difficulty obtaining 60-pound paper, 100-pound paper was substituted and found to perform equally as well.[29]

Sheets were thoroughly pasted on one side and allowed to soak, after which they

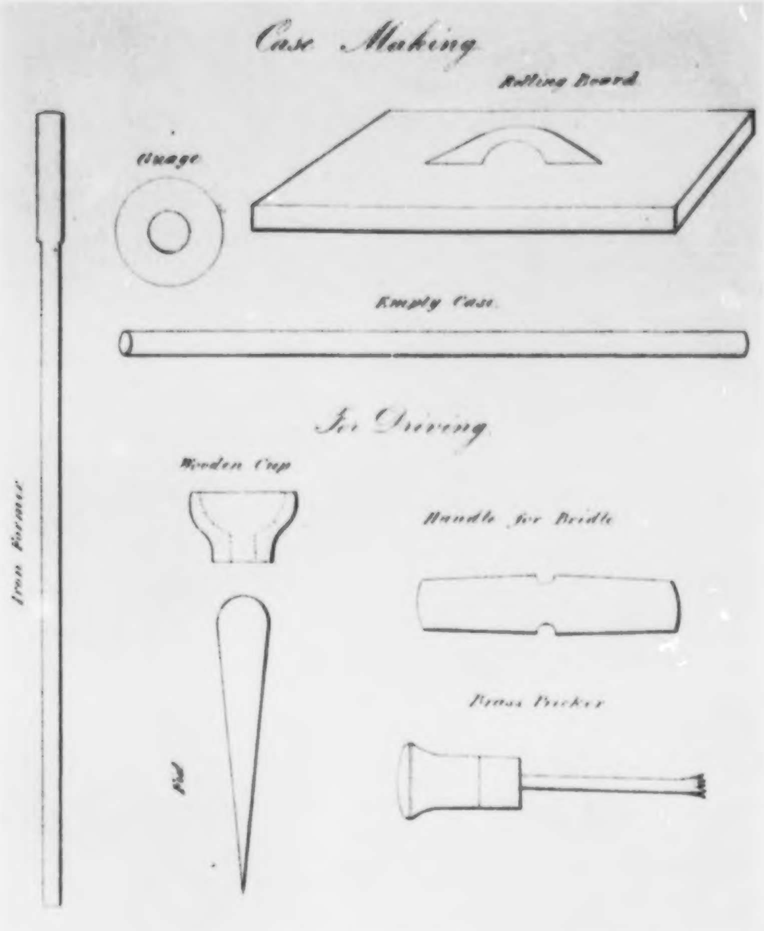


Figure 233. Implements Necessary for Making Common Portfires. (The Royal Artillery Institution, Woolwich, U.K., "Artillery Implements...")

were wound round a former and rolled under a rolling board (Fig. 233). Then, the resulting cases were gauged, paper being added or taken away to meet the required dimensions. When they were the proper size, they were removed from the former and allowed to dry.

When a case was thoroughly dry, one end was turned in, layer by layer with a metal pricker, to form a bottom (Figs. 233 and 234). It was then placed in a hollow brass mould, somewhat shorter than the case. Details of the mould's design varied from time to time; around 1800 it was tightened by slipping brass rings over it, but by the 1820s three screws secured it. Once the case was secured in the mould, the longest of the four drifts was inserted into the case and given three or four blows with a mallet to set the bottom properly. Various methods of opening the end of the case to prevent spillage of the composition were practiced, but by the 1820s a small wooden cup was placed over the end of the case which was protruding from the mould and the excess paper was cut off even with the cup's surface. Then a small fid, something like a marline-spike, was introduced to open up the top of the case; the purpose was to prevent spilling as the composition was poured in, the cup and opened case acting like a funnel. A ladle of composition was put in, a drift inserted, and 15 blows given it to set the composition; as the case filled the shorter drifts were used. When the case was filled to about 0.1 inch from the top of the mould, the cup was removed and the case cut off even with the top of the mould. It was then primed with a paste of mealed powder and spirits of wine.

When the priming had dried, the portfire was painted; in the 1860s flesh colour was used.[30] Until about 1855 the paint used was oil based, but when it was discovered that the oil was injurious to the composition, methylated spirits were substituted. In the 1860s each portfire was marked with the date of manufacture and the driver's name; it is not clear how they were marked before then. They were tied up in bundles of 12 and the whole lot was covered with a cap of brown paper tied on over the open ends.

Portfires were used to carry fire from the slow match burning on the linstock to set alight the loose priming or the tube to discharge the piece. After the invention of the friction tube in the 1850s, the portfire was no longer necessary, but it continued to be issued in case of the lack of friction tubes or of their failure. If the piece was not to be fired again immediately, the end of the portfire was cut off with a portfire cutter. Its time of burning varied somewhat between 13 and 16 minutes, but a rate of slightly more than 1 inch per minute was given in the 1860s.[31]

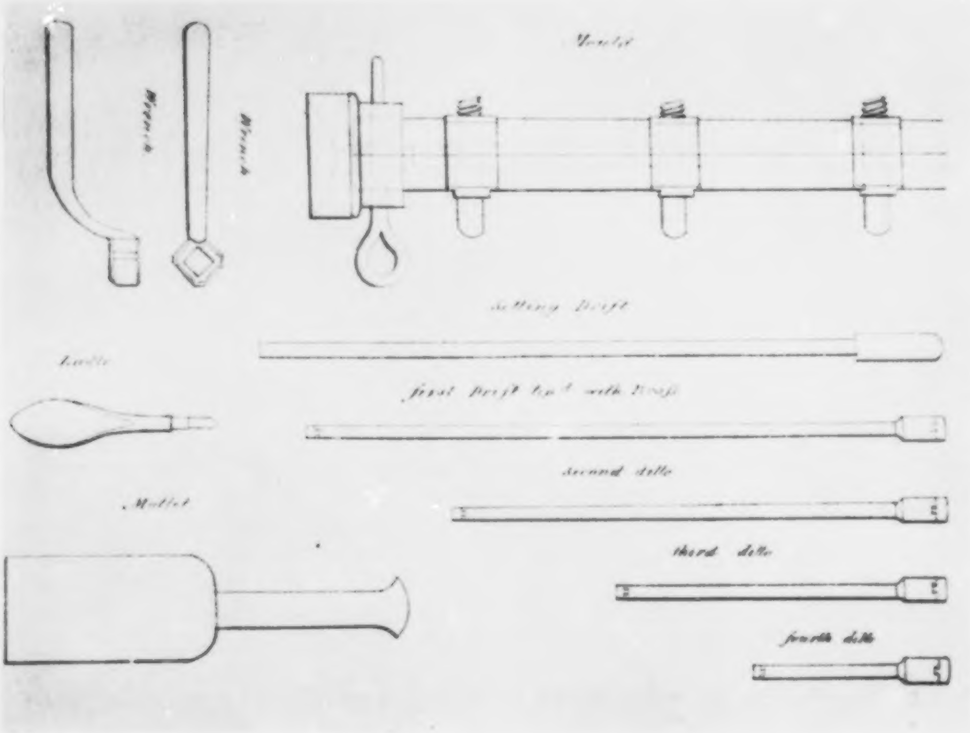


Figure 234. Implements Necessary for Making Common Portfires. (The Royal Artillery Institution, Woolwich, U.K., "Artillery Implements...")

Tubes

It has previously been pointed out that a piece of quick match inserted into the vent of a piece, when ignited, would transmit the fire almost instantaneously to the powder chamber. The discovery of this power of quick match resulted in the invention of the first true tube, probably sometime in the first half of the eighteenth century; it was certainly in service by 1755. This first tube was a tin cylinder about 0.2 inch in diameter, sufficient to enter the vent of a piece of artillery. A cup-shaped head was attached, probably soldered, to one end; the other end was cut on a slant like a pen and may have been strengthened with solder to enable it to pierce the cartridge. The diameters of the cup and cylinder and the length of the slant cut were the same regardless of calibre, but the length varied depending on the thickness of metal at the vent to allow the tube to pierce the cartridge. A piece of quick match was threaded through the tube and the cup was primed with a paste of mealed powder and spirits of wine. Muller wrote that paper, which was removed when the tube was to be used, was tied over the cup. Later, he claimed, a flannel cap, steeped in a solution of saltpetre and spirits of wine, was used; it did not need to be removed because it took fire as quickly as the priming.

The development of the tin tube improved the practice of artillery. Since its use obviated having to thread a piece of quick match into the vent, the rate of fire could be increased, an improvement of some importance, especially to field artillery. Enclosing the match in a cylinder also gave greater protection to the vent, slowing down the speed of its corrosion. Also, it was a safer method of firing because a train of loose powder no longer had to be used to prime the gun. On the other hand there were some problems. It was alleged that the tin would spoil the match if the tubes were stored too long. Although there was a reference to the use of tin tubes at the battle of Quiberon Bay in 1759, generally the naval service disliked them. Salt water corroded them quickly, and they cut the sailors' bare feet on the fighting decks after they had been used.[32]

The next improvements in the manufacture of tubes – the adoption of a uniform length and the use of composition instead of quick match – may have been inspired by European practices. Certainly the British were aware that continental nations used other materials and methods. Muller wrote:

> The French use a small reed, to which is fixed a wooden cap about two inches long; they are filled with mealed powder moistened with spirits of wine, and a small hole is made through them the size of a needle, through which the fire darts with great violence, and gives fire to the cartridge which must be pierced beforehand with the priming iron.[33]

Whatever the precise origins of the reforms, by at least 1788, the British were using quill and tin tubes, of a uniform length, driven with composition, and pierced longitudinally. The anonymous writer of a notebook, circa 1797, declared that "After repeated experiments for many years with about 40 different Inventions of Tubes, these two kinds were approved as fittest, for service."[34]

The choice of 1788 is at variance with the conclusion that Majendie came to in his authoritative study of smooth-bore ammunition and perhaps needs further argument. Citing Adye's publication of tables of variable length tin tubes in 1813 and 1827 and Spearman's publication of tables of uniform length for metal and quill tubes in 1828, Majendie argued that the changeover to a uniform length took place sometime between 1813 and 1827.[35] But in one of Sir Augustus Fraser's notebooks the following statement appeared:

> N.B. Worsted quickmatch no longer in use since 1788. The Short Tin and Quill Tubes being filled with Composition.[36]

Also, an anonymous manuscript notebook, circa 1797, gave two tables of the amounts of materials and the costs of labour to make 1000 quill tubes and 1000 short tin tubes, both lists dated October 1790. It is clear from the tables that composition, not match, was used and that the composition was pierced. Further, a notebook of Sir Augustus Fraser gave details for making quill tubes and for filling both quill and tin tubes, dated 1800. It may well have been that the older tubes were still being used in the early nineteenth century, but it seems clear that innovations had been adopted by the end of the 1780s.[37]

More is known about the introduction of quill than of the short tin tubes. In 1778 when he was placed in command of H.M.S. Duke, Sir Charles Douglas proposed to the Admiralty the adoption of quill tubes along with flannel cartridges and flintlocks. The Admiralty was not immediately responsive to his suggestions, but at his own expense he equipped his ship with quill tubes as well as flintlocks and flannel bottomed cartridges. His foresight was amply rewarded for on 12 April 1782 the British won a major naval battle in the West Indies due in part to his innovations. The victory ended the need for innovation, however, and it was not until the end of the decade that quill tubes, along with flint locks, were adopted into the naval service.[38]

The manner of manufacturing quill and short tin tubes changed very little, if at all (Fig. 235). Goose quills were gauged to 0.2 inch, scrapped to clean them, and cut at both ends to about 3 inches in length. (It seems strange to gauge them and then clean them, but this is what the sources appear to say.) Then the quills were cleared of pith by passing a small iron or brass wire through them. Next they were placed individually into a special machine which held them firmly with about 1/4 inch of the large end protruding; a seven-edge slitting knife was introduced into the large end to slit it into seven prongs. The quill was removed from the machine, the prongs were laid out almost flat, and a worsted thread was intertwined through them to form a shallow cup about 7/10 inch in diameter. To finish it off, the worsted was stitched all round on the outside between each prong to secure it in place. It was now ready for filling with composition (Fig. 236).

Tin and quill tubes were filled in the same way. The composition of mealed powder was dampened with spirits of wine and well mixed. The workman closed the large end with the thumb of his left hand and dug the small end into the composition; he gently drove home the composition thus collected with a small drift. This operation was repeated until the tube was completely filled. Then the cup was filled with priming paste and dusted with mealed powder; the other end was carefully wiped dry. A fine wire was inserted through the small end the length of each tube and the tubes were set aside to dry, the wires being turned periodically to prevent their sticking. When the tubes were dry, the wires were removed. Finally the heads of the tubes were capped with paper, twisted on, which was removed before the tubes were to be used. They were usually packaged up in paper parcels of 100.[39]

Another tube, which was known in the British service but was not widely used or only in emergency situations, was the Dutch or paper tube (Fig. 236). It was made from small arms cartridge paper cut up into pieces about 5-1/2 inches by 2 inches, pasted, and rolled on a former into hollow cases. They were gauged, cut to a length of about 1-3/4 inches, and dry rolled. A strip of cartridge paper 17 inches long by 4/10 inch broad was wound around one end, each turn overlapping the last slightly, to form a cup. Paper tubes were strengthened with two coats of blue paint before they were filled and pierced in the manner described above. Priming was slightly different; the paste was shaped into a cone protruding out of the cup. Paper caps were tied on. Later sources said the paper was dipped in a saltpetre solution, making it unnecessary to remove the caps before the tubes were used.[40]

The match or Fynmore's tube (its name deriving from Lt. Fynmore, R.N., who proposed it) was similar to the quill tube (Fig. 236). It differed in having eight strands of worsted, each 2 inches long, protruding from the cup. The strands were smeared with a thick paste of mealed powder, methylated spirits, and gum arabic, and then drawn through dry mealed powder. When the tube was inserted in the piece, the worsted strands, instead of priming powder, were laid in the pan of the flintwork. These tubes were adopted sometime between 1818 and 1824, but it is not clear how extensively they were used.[41]

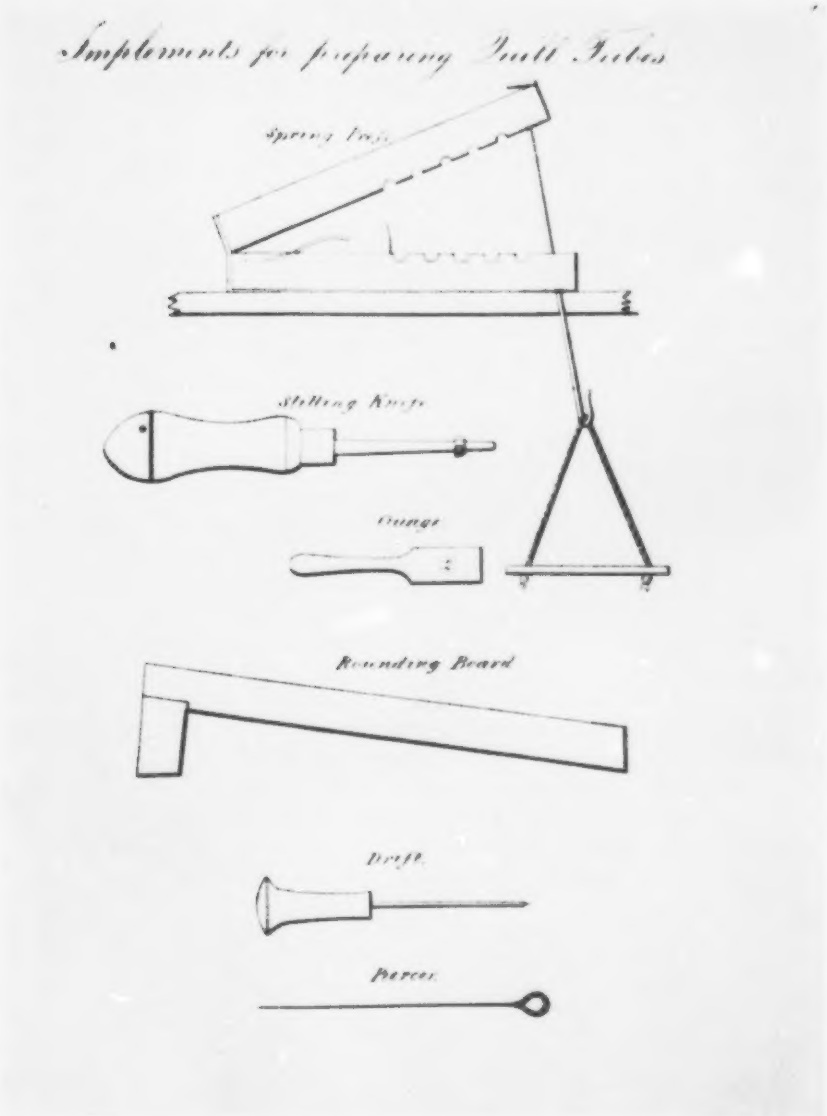

Implements for preparing Quill Tubes
Spring Press
Slitting Knife
Gouge
Rounding Board
Drift
Piercer

Figure 235. Implements for Preparing Quill Tubes. (The Royal Artillery Institution, Woolwich, U.K., "Artillery Implements...")

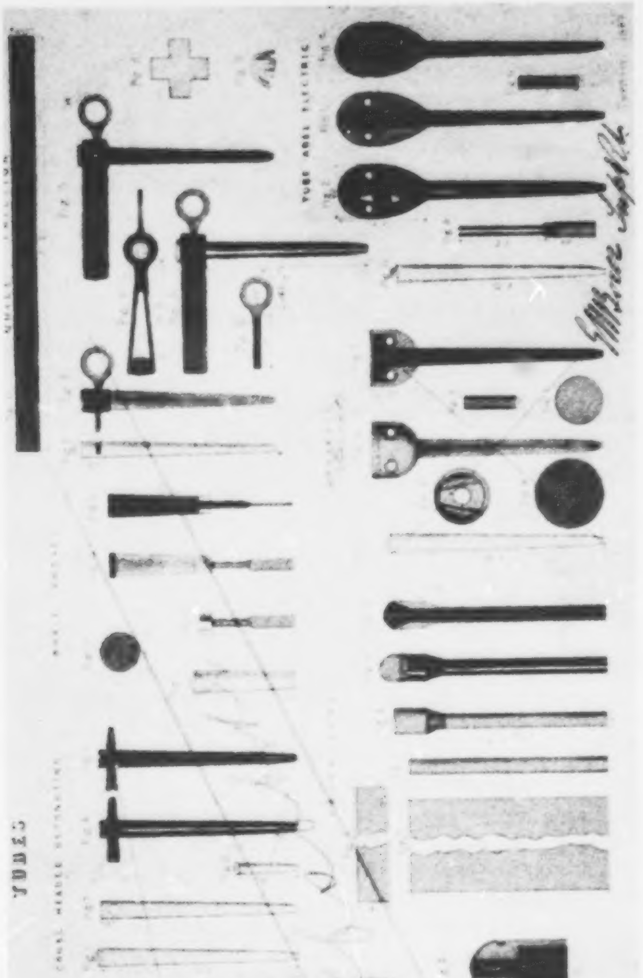

TUBES
TUBE ABEL ELECTRIC
FUZE ABEL ELECTRIC
COPPER FRICTION

Figure 236. Tubes. (The Royal Artillery Institution, Woolwich, U.K. Royal Laboratory, Plate 5, December 1867.)

The next major innovation was the development of detonating or percussion tubes. Although there was some suggestion that experimental models were made earlier, the first service detonating tubes were manufactured for the navy in 1831 on the proposal of a Mr. Marsh of the Royal Arsenal Surgery. It was composed of a main quill filled with normal composition, and a side quill, fixed at right angles to the body near one end, filled with a detonating composition. This was made up of half chlorate of potassa and half sulphuret of antimony. The two tubes were cemented at the joint and the whole was varnished with red sealing wax dissolved in spirits of wine. These were known as "rectangular percussion quill tubes."[42]

This tube was fired by a percussion lock, the hammer striking the side tube that held the detonating composition. Because the detonating composition was off to one side, the hammer was not blown back by the explosion from the vent, but the tube seems to have been relatively sluggish in action. Various experiments with tubes and locks were tried, including a "crutch-tied" tube in which the detonating quill was tied across the top of the main quill, a notch or crutch having been cut therein to receive it.[43]

Although the navy had adopted the "rectangular percussion quill tube" in 1831, the Royal Artillery accepted it for garrison and seige (but not field) service only in November 1845. Its career thereafter was short, however, for in 1846 Colonel Charles C. Dansey, Chief Firemaster, Royal Laboratory, Woolwich, introduced a "cross headed detonating quill" which was adopted by both the land and sea service (Fig. 236). At the same time, a special lock devised by Colonel Dundas was adopted, in which the hammer was pulled back from over the vent after it had struck the detonating composition; this movement preserved the lock from serious damage from the explosive force emanating from the vent.

The body of the tube was made of goose quill 2.5 inches long, cleared of pith, scraped clean, and gauged in the usual manner. Its small end was snipped off, and as near its large end as possible a hole was drilled through both sides. The tube was filled with composition and pierced as usual. Then a small pigeon's quill or "snipe," which had been filled with detonating composition, was inserted into the hole and secured with fine silk. The detonating composition was a mixture of

Potash, chlorate of	6 oz.
Antimony, sulphide of	6 oz.
Glass, ground	1 oz. 10 dr.

dampened with spirits of shellac. The open end of the snipe was closed with shellac putty. The small portion of the main tube above the snipe was filled with a small amount of L.G. powder to increase the flash and closed with shellac putty. Early on the body of the tube was varnished black and the head and snipe were covered with a thicker red varnish; after 1857, it seems that the whole was varnished black.[44]

This detonating tube was an improvement over the "rectangular percussion quill tube," but it still presented problems. Considerable force was required to crush the quill above the cross of the snipe and the main tube, and there was the danger that if the lanyard were not pulled sharply enough (the hammer was not spring released), the hammer would only bruise the composition and not explode it. Also, where the vent had become enlarged with wear, if the blow was not strong enough, the snipe could become doubled up and driven into the vent; this would cause delay and danger to the gunner removing the tube.[45]

The final solution was the development of the friction tube – copper for land service and quill for sea service. The initial inspiration came from a German officer, a Lieutenant Siemans, whose metal friction tubes were ordered to be made in the Royal Laboratory for experiment in 1841. Tests seem to have been made throughout the 1840s, but it was not until 1851 that a Mr. Tozer of the Royal Laboratory perfected the copper friction tube. It was adopted into all branches of the land service (field, garrison, and seige) on 24 June 1853. Because it was metal it was deemed unsuitable for the navy, and it was not until 16 July 1856 that a quill friction tube, designed by Boxer, was adopted into the latter service.[46]

The main tube was made out of sheet copper, rolled, gauged, and cut into 3 inch lengths (Fig. 236). A nib was also stamped out of sheet copper; it was rolled into a short tube, but it was designed with two projecting stubs to fit round the main tube. It was attached to the main tube at a right angle near one end, woolded with copper wire and soldered into place. A drill was inserted into the nib and a hole drilled into the main tube. Then the main tube was driven with composition (mealed powder slightly dampened with methylated spirits) and pierced with a fine wire along its length. A friction bar, which was stamped out of a piece of copper and roughened on both sides, was inserted into the nib, and a small piece of detonating composition was placed above and below it. The nib was then flattened with pincers onto the bar and detonating composition. The projecting end of the bar, which was circular to take the hook of the lanyard, was turned up slightly to ease its attachment. The top of the tube was closed with shellac putty and the bottom with a disc of fine white paper, varnished on. The end of the nib was varnished thickly and the whole tube was varnished black to exclude moisture as much as possible. The tube was fired by withdrawing the bar by a sharp pull on the lanyard, the friction between the roughened bar and the detonating composition exploding the latter and igniting the tube.[47] The detonating composition was made of

Potash, chlorate of	6 oz.
Antimony, sulphide of	6 oz.
Sulphur, sublimed	1/2 oz.

dampened with a mixtured of methylated spirits and shellac; the appropriate sized patches were then dried for use.[48]

The principle of the quill friction tube was the same, although some details of construction varied (Fig. 236). The body, about 2-1/2 inches in length, was made of quill, cleaned of pith, its end nipped off, and gauged in the usual way. It was driven with the usual composition and pierced. Near its large end two transverse slits were cut, through which the copper friction bar, roughened only on its upper side, was inserted. The protruding roughened end of the bar was bent downward slightly to increase the friction when withdrawn, and the end with the loop was twisted so that the loop was vertical rather than horizontal to facilitate the attachment of the lanyard. To strengthen the tube it was woolded with fine copper wire above and below the slits for the friction bar. A small quantity of detonating composition, dampened with methylated spirits and shellac and not dried, was driven inside the quill on top of the friction bar. It was slightly different than that used in copper friction tubes:

Potash, chlorate of	6 oz.
Antimony, sulphide of	6 oz.
Sulphur, sublimed	1/2 oz.
Powder, mealed	1 oz.

The addition of the mealed powder was to ensure a longer lasting flash, since only one pat of detonating composition was being used. Over the detonating composition a little gunpowder was driven; then a little ground clay; it was finished off with beeswax. The upper part of the tube and the roughened, protruding end of the friction bar were varnished and the latter was dipped in ground glass to increase friction. A small parchment cap was then tied over the top with fine kitted silk.

The original quill detonating tube was fitted with a leather collar around its upper end, tied on with kitted silk, which formed a loop about 1-1/2 inches long. This loop passed over a metal pin near the vent which took the strain of the pull of the lanyard, preventing the quill from breaking. From 1859 to 1865 this loop was dispensed with, being replaced by a leather band around the tube which filled up a metal crutch placed alongside the vent to support the tube. After 1865 the quill friction tube was manufactured with a loop again, of which there were two patterns of little difference in design.[49]

Locks

The introduction of the use of flint-locks to fire guns in the naval service is usually attributed to Sir Charles Douglas' personal initiative between 1778 and 1782, but the naval historian Dudley Pope has discovered an Admiralty order, dated 21 October 1755, which stipulated that locks were to be fitted to all quarter deck guns and to be introduced gradually to all other guns.[50] It is by no means clear, however, that this order was widely followed or, indeed, followed at all. If locks were introduced to some extent in 1755, their use seems to have been forgotten by 1778 when Douglas was placed in command of H.M.S. Duke. He entered into discussions with the Admiralty to introduce flannel cartridges, quill tubes, and flint-locks, but he was largely unsuccessful, receiving only eight locks in 1779. Undaunted, at his own expense he furnished his ship with flannel, goose quills, and flint-locks. The performance of the Duke during Rodney's celebrated victory over the French in the West Indies at the Battle of the Saints, 12 April 1782 (although Douglas had by then been transferred to another ship) confirmed the efficiency of the flint-locks. The ending of the war seems to have delayed their introduction, and it was not until 1790 that a new pattern of "brass locks" was generally introduced into the British naval service.[51]

The common naval flint-lock continued in use throughout the wars with France and Napoleon, but its performance was open to some criticism. In particular, it was pointed out that if the flint failed during the heat of battle, it was rarely replaced immediately because of the difficulty of fixing a new one quickly and properly. If it were not precisely aligned, it could break or even cause premature ignition as the pan was closed. Consequently, upon the failure of the flint recourse was had to the portfire, the use of which the flint-lock was supposed to obviate.[52]

In an attempt to increase the efficient use of the flint-lock, Sir Howard Douglas, Sir Charles Douglas's son, submitted to the Admiralty in 1817 a new design of lock (Fig. 237). It was fitted with double jaws holding two flints, held in position by a notch and a wing nut. If one flint failed, the other could be brought into play in four or five seconds by loosening the nut, pivoting the double jaws, realigning their shaft in the notch, and tightening the nut. Then "... the back flint may be replaced at comparative leisure whilst the gun is re-loading, without disarming the lock of its efficient flint."[53] Moreover, not only could this be done quickly, but there was no danger of losing loose parts since the double lock was self-sufficient.[54]

The admiralty tested the double lock, probably in August 1817, and reported that they "... are considered to be a very great improvement on those at present in use."[55] On 16 January 1818, Douglas was advised further "... that the provision of locks for Sea Service Ordnance now in use, should be discontinued, and those of your invention gradually introduced into the service."[56] The Board of Ordnance, on the other hand, was more cautious and initially declined to make a decision. Douglas enlisted the aid of Sir Alexander Dickson, a distinguished artillerist and Wellington's chief of artillery during the Peninsular campaigns and the subsequent invasion of France. Dickson argued strongly for the adoption of the new locks by the Royal Artillery, supporting Douglas' argument of the inability of gunners to change flints both quickly and properly, and adding that lighted portfires were dangerous in batteries because of the presence of powder in a busy and confined space. He had reservations about the use of a lock in the field service, unless a new tube was adopted (Douglas had a proposal); using the existing tubes it was necessary to prime the lock with powder. On the other hand, he pointed out the danger of setting fire to dry grass, corn, houses, and villages, when the burning ends of portfires were cut off, and the trouble of continually lighting, cutting, and relighting portfires.[57]

According to Douglas,

> Supported by that distinguished officer, the author's proposition received favourable consideration, and would then have been carried into effect had not financial and other considerations rendered it inexpedient to provide forthwith the necessary supply of locks.[58]

The possibility that the Royal Artillery never used this flint-lock was to some degree contradicted by Majendie in his study of smooth-bore ammunition although he does

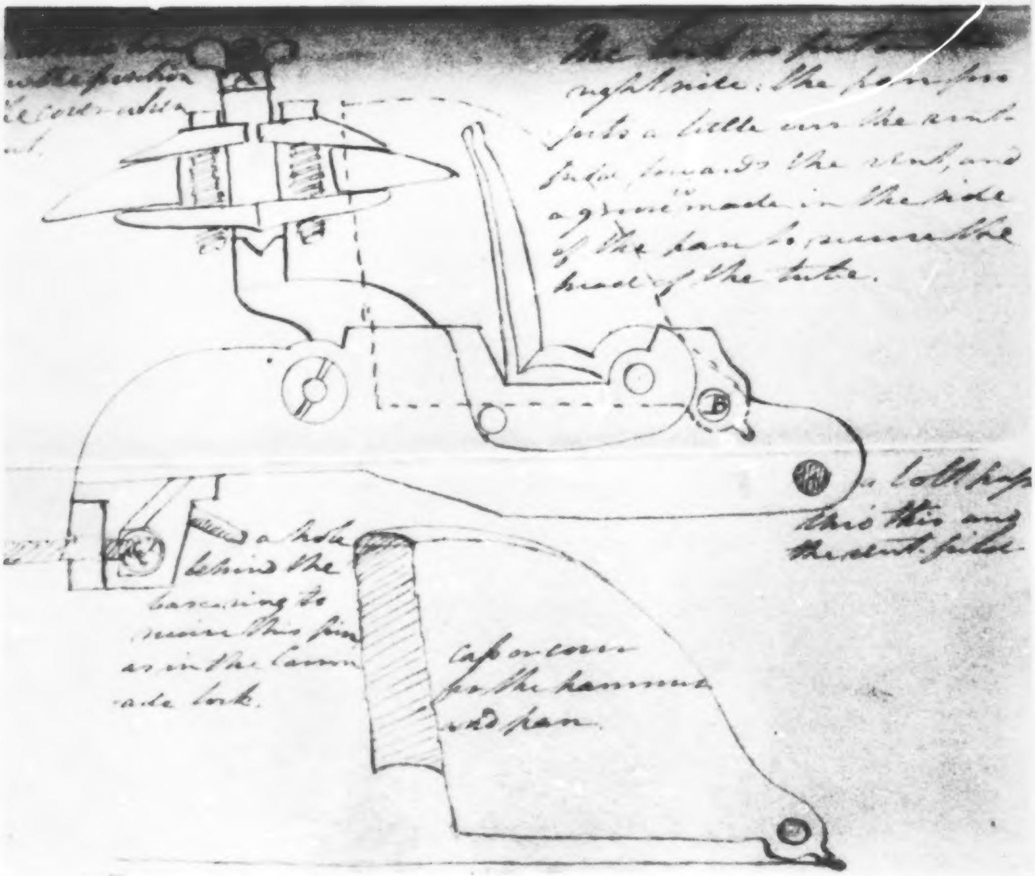

The lock is put on the
right side. The pan pro-
jects a little over the vent-
field towards the vent, and
a groove is made in the side
of the pan to receive the
head of the tube.
B
a bolt keeps
thro' this and
the vent-field
a hole
behind the
base-ring to
receive this pin
as in the Carron-
-ade lock.
Cap or cover
for the hammer
and pan

Figure 237. Douglas Gunlock. (The Royal Artillery Institution, Woolwich, U.K., Lefroy, Papers.)

not cite any specific evidence. After quoting the above statement by Douglas, he went on:

> But there is no doubt flint locks were used for land service to a certain extent, and I conclude therefore that the passage refers merely to a lock of a particular construction, and not to locks generally.[59]

But he conceded:

> ... their employment for land service never became general, and a large, probably the larger, proportion of land service guns continued to be fired with common ... tubes by the application of a lighted match or portfire.

The development of the detonating or percussion tube in the 1830s required coincidentally the design of a different lock, one whose hammers would explode the detonating composition by striking it. If the tube were so designed that the hammer came down on the detonating composition directly over the vent, unless the hammer could somehow be pulled away, [illegible] would be thrown back violently by the explosion of the charge issuing through the vent, thereby in all likelihood damaging the lock and putting it out of action. Consequently, the first percussion tubes were so designed that the detonating composition was attached to one side of the tube, and the hammer of the lock thus came down to one side of the vent. Unfortunately, this arrangement was found sluggish and unsatisfactory.

Various designs of locks were put forward to allow the hammer to fall directly over the vent and instantaneously allow it to slip or be drawn away, but the simplest and most efficient was patented in 1842 by an American named Hidden. The hammer of this lock was modified and improved by Colonel Dundas, and on 2 October 1846 Hidden's lock as modified was adopted into both services.[61] The hammer, which was made of the best wrought iron and weighed about 3-5/16 lb., was attached to a gun-metal block upon which it rotated. A slot was made in the hammer so that when it was jerked forward upon the vent by the pull of the lanyard it was instantly shifted backward by the continued action of the lanyard. Although this device was ingenious and simple, it had its shortcomings. Its firing action was not as quick as if the hammer was spring propelled. Also, crushing the top of a cross-headed detonating tube required a strong pull on the lanyard; if it was insufficient, the composition would not be exploded but rather the tube driven into the vent, resulting in delay and danger in its removal. It is not clear how widely this percussion system was used, but shortly it became obsolete with the development of friction tubes in both the land and sea service (see above).[62]

SIGHTS AND SIGHTING

To hit a target with a projectile a gunner had to lay his gun properly. He did this by aligning the axis of his piece and the vertical plane of the object and, unless it was point blank range, by giving the gun some elevation above the horizontal plane that passed through the target. Since guns had no sighting devices originally, laying was done most crudely. In the field, the gunners usually opened up at point blank range; during sieges, they usually determined the elevation by experience and trial and error.[1] In 1610 a dispart sight, set on the muzzle to make up the difference in diameter between the base ring and the swell of the muzzle, was used to lay the gun point blank, and in the mid-1700s such a device was still in use, but usually only in practice.[2] To aid the gunner a button or acorn was cast on the mid-point swell of the muzzle and a notch or cavity in the mid-point of the base ring; lining these two points up with the target gave the proper line of direction.[3] According to John Muller, who was writing in the 1750s, pieces were formerly cast with these sights, but there is no other evidence that English guns were so marked in the eighteenth century. Rather, the gunner found the line of direction by establishing the centre points of the base ring and the swell of the muzzle, using a plumb-line or spirit level, and by joining them with a chalk line, although Muller felt that this method was "... very tedious, uncertain, and unmasterly."[4] In 1766 Adye described the devices used to lay a gun — the dispart sight; the line of direction, determined by spirit level and marked with chalk; and, for determining elevation, the gunner's quadrant.[5]

Invented about 1545 by Niccolo Tartaglia, an Italian mathematician and pioneer ballistics theorist, the gunner's quadrant was a simple and effective device for determining the elevation of a piece. It was constructed in wood or metal of two arms of unequal lengths joined in a right angle and connected by a half circle graduated in degrees. A plumb-bob on a thread was suspended from the vertex of the angle. The long arm was inserted into the bore of the piece and the angle of elevation was read at the point the thread of the plumb-bob touched the quarter circle. Angles of depression could be determined by placing the long arm flush on the face of the muzzle and again determining where the thread touched the quarter circle.

A variation of the gunner's quadrant was the spirit level quadrant, in which a spirit level was pivoted from the vertex of the right angle and the angle of elevation read from where it intersected the graduated quarter circle. It was used similarly to the gunner's quadrant — the long arm was inserted into the bore of the piece, the spirit level adjusted until it was level, and the angle of elevation determined from the scale on the quarter circle. Angles of depression were determined by placing the short arm flush on the muzzle face or if the bore were large enough, into the bore, and adjusting the level.[6]

The spirit level dates from 1661, but it is not known precisely when it was married to the gunner's quadrant.[7] In the catalogue of the Museum of Artillery at Woolwich there is a record of "Brass instrument (quadrant with spirit level and plummet index) for laying guns and mortars" attributed to Albert Borgard and dated 1710.[8] Although Adye mentioned only the gunner's quadrant in his notebook of 1766, John Muller described the spirit level quadrant two years later:

> The best sort has a spiral [sic] level fixed to a brass radius, so when the long end is introduced into the piece, this radius is turned about its centre till it is level, then its end shows the angle of elevation, or the inclination from the horizon ....[9]

How extensively it was used may have been a function of its cost compared to the gunner's quadrant. Along with the latter it continued to be mentioned into the 1860s. A scale drawing in a repository course notebook, circa 1826, showed a rather compact instrument, equipped with a vernier to read to quarters of a degree and with a screw device to adjust the level finely.[10]

Although Tartaglia and other writers constructed elaborate theories of ballistics around the use of the quadrant, it is unlikely that it was used very often in the heat of battle. Commenting on the use of various instruments, including the gunner's quadrant, in 1766 Adye remarked:

> These Instruments may be very well used in practice as they serve to show a Young Artillerist on what Principles his Business is founded, but are seldom made use of in real Service, as it must render the firing very slow & tedious & if the Gunner finds his Gun throw at first either too high or too low or too much to the right or left, he can easily alter it by his Eye without the Assistance of an Instrument.[11]

Later, with the development of tangent sights, the use of the quadrant was probably even more restricted, although its use was still taught and it continued to be issued. In 1864 Miller indicated that for the field service one quadrant was issued to each rocket carriage (but not to the field guns), eight were considered adequate for a siege train of 105 pieces, and one was issued to every four mortars (but not to the guns) in garrison.[12] Clearly its use was limited and it was largely superseded by the tangent scale.

A tangent scale was a laying device marked off in quarter degrees, which allowed a gun to be elevated the required number of degrees above the horizon, depending on the range of the target. The length of each degree of elevation on the scale could be determined by multiplying the distance between the two sights on the piece (e.g., between the base ring and the swell of the muzzle, or between the base ring and the dispart sight) by the tangent of the number of degrees of elevation required, which could be obtained from trigonometrical tables. A manual gave the following natural tangents:[13]

1/2 = .00872
1 = .01745
1-1/2 = .02618
2 = .03492
2-1/2 = .04366
3 = .05240
3-1/2 = .06116
4 = .06992
4-1/2 = .07870
5 = .08748
5-1/2 = .09629
6 = .10510
6-1/2 = .11393
7 = .12278
7-1/2 = .13165
8 = .14054
8-1/2 = .14945
9 = .15838
9-1/2 = .16734
10 = .17632

(A modern table gives a variation of .00001 in some of the tangents, which is so slight as to be insignificant.) If the piece did not have a dispart sight, the length of the dispart (one-half the difference in diameter between the base ring and the swell of the muzzle) had to be subtracted from lower end of the scale to establish the lowest elevation at which the gun could be laid using the scale, i.e. the line of metal elevation. For elevations below this to point blank the quarter sights had to be used. If the piece had a dispart sight, which field guns in the late 1850s and howitzers had cast on, the dispart was not subtracted, and the tangent scale could be used to lay the weapon from point blank upwards.[14]

The tangent scale may have been first suggested by Thomas Blomefield in the mid-1770s, who, in a paper before the Military Society at Woolwich, proposed:

> that the tangents for every 1/2 degree of elevation be calculated from point blank to 6°, according to their different lengths, which graduated upon a small scale with sights might be fixed or occasionally applied to the base ring.[15]

It is not known when the tangent scale came into general use, but Blomefield's position as Inspector of Artillery in the 1780s would have facilitated its development. Certainly by the late 1790s brass guns were being cast with a block behind the base ring for the drilling of a hole into which the tangent scale fitted.[16] Older brass guns could be fitted with a tangent scale by attaching with screws a holder to the cascable in which the scale could slide (Fig. 238).[17] A tangent scale could be attached to any gun, but initally it was used only with brass field pieces, in particular the following:

pdr.		**ft.**	**in.**
12,	medium,	6	6
	light	5	
6,	heavy	7	
	light	5	
3,	heavy	6	
inch			
10,	howitzer	3	11-1/2
8		3	1
5-1/2		2	2-3/4
4-2/5		1	10[18]

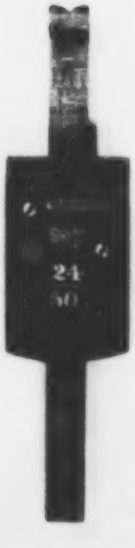


Figure 238. Brass Tangent Scale for Old Brass Guns. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXIV/50.)

According to Landmann, the tangent scale

> consists of a piece of brass 0.6 of an inch in diameter, applied to the breech of guns and howitzers; and, sliding in a grove [sic], cut through the cascable: the back has a small flat surface on which the divisions are made for elevating the piece: there is a notch also upon the top of the scale corresponding with those upon the base-ring and the swell of the muzzle. A small screw is contrived to fix the scale in any given position.[19]

Suggestions were made to engrave the distances corresponding to the degrees of elevation, and tests were carried out in 1813 with scales on which were marked the spherial case fuze letter, the fuze length, and the range. Marking the scale in this way seems not to have become common practice, however (Fig. 239).[20]

Quarter sights, which complemented the tangent scale on field guns, were developed concurrently with it.[21] They allowed for elevations down to point blank, the tangent scale being useless below the line of metal elevation. They were cut on the upper quarters of the base rings in quarter degrees from point blank to 3 degrees, thus allowing some overlap with the elevations of the tangent scale. The point blank sights were obtained by cutting a notch on both sides of the muzzle swell and base ring so that a line joining them would pass slightly above the trunnions, parallel to the axis of the bore. The other quarter sights were then cut on the base ring, the lengths of the degrees being tangents calculated from the long radius of the gun. These lines, along with the centre point on top of the base ring and the swell of the muzzle, were ordered cut on guns from the late 1790s. Although the development of Millar's sights obviated quarter sights, as late as the 1860s quarter sights were cut on all brass guns and land service iron guns, 32-pounders and and lesser calibres.[22]

Detailed descriptions of the method of cutting the visual lines on guns have not been found until the 1840s, but it seems unlikely that they varied greatly before then. For reasons which are not apparent, there were some differences between the methods used for brass and iron guns. For the former, the gun was placed with its trunnions perfectly horizontal, and the centre point on the base ring and the muzzle was determined with a spirit level; these points were joined with a straight edge, marked, deepened with a chisel, and finished with a file. To establish the lowest quarter sights on the base ring and muzzle swell, a semi-circle equal to half the base ring and another equal to half the muzzle swell were inscribed from the same centre on a plate of brass. A line was drawn 3/4 inch above, and parallel to, the common diameter of the two semi-circles; the 3/4 inch represented the thickness of the capsquares. The radius was set off from the common centre perpendicular to the diameter of the semi-circles. On each semi-circle the distance between the points where the perpendicular and the parallel line intersected the semi-circle was measured with callipers, and that distance, measured from the centre point already cut, was marked on both sides of either the base ring or the muzzle.

To determine the remainder of the quarter sights, a brass template with one edge curved to fit the base ring and the opposite edge straight was used. The tangents for each quarter degree of elevation up to 3 degrees, calculated for the long radius, were marked on the straight edge, and perpendiculars were drawn to intersect the curved edge. The template was applied to both sides of the base ring and the scale transferred on to it; the marks were finished with chisel and file, a straight edge being used to join each mark to that on the side of the muzzle swell.

Iron guns were treated somewhat differently. To establish the centre points on the base ring and the muzzle swell, the trunnions were levelled and a long batten, with a line bisecting it lengthways, was put down the bore of the gun. The batten was levelled and a perpendicular was raised from the bisecting line against the muzzle

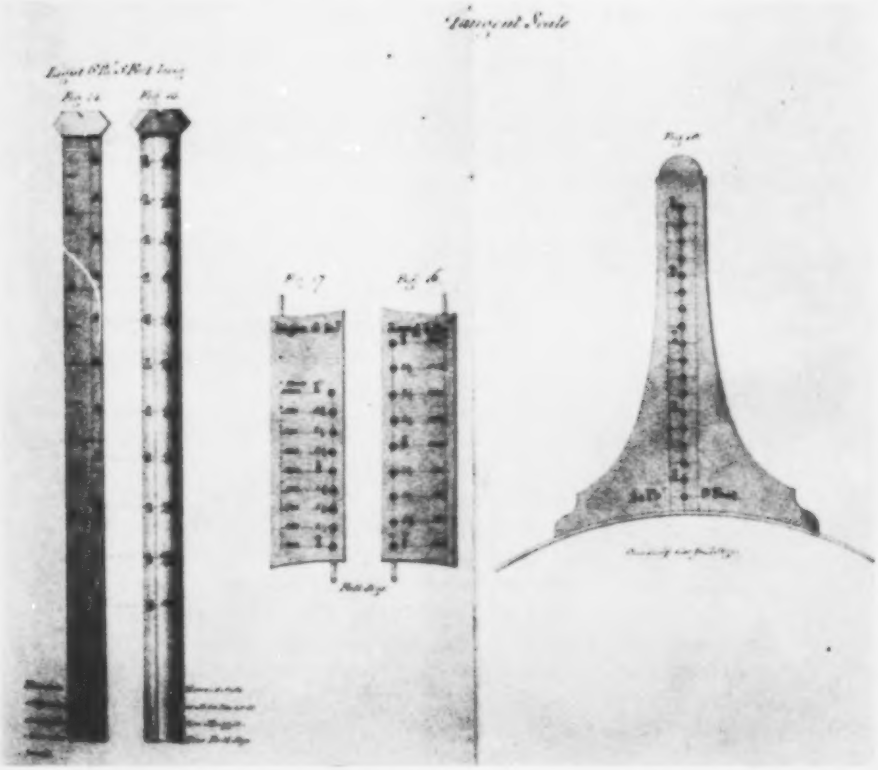


Figure 239. Tangent Scales. (The Royal Artillery Institution, Woolwich, U.K., "Repository Course...")

face. Another batten was placed along the upper surface of the gun from the base ring, touching the perpendicular, and made to coincide with the centre line of the batten extending from the bore. The points where the batten touched the base ring and muzzle swell were marked. The batten was reversed and the points marked again; if they did not coincide the mid-point between the two marks was selected. They were deepened with a chisel and finished with a file. The line between the cuts on the base ring and the muzzle should have been coincidental with the axis of the bore.

To mark the lowest quarter sights, the inclination of the bore was taken with a quadrant spirit level. A piece of iron the thickness of the capsquares (about 1-1/2 inches) was placed on the trunnions, and a batten was balanced on it at the same angle as the bore. Marks were made where the batten touched the base ring and the muzzle swell on both sides; they were deepened with a chisel and finished with a file. The remainder of the quarter sights were marked in the same way as they were on brass guns.[23]

The centre of metal was cut on the base ring and the swell of the muzzle on both sides, and on the face of the right trunnion after 1860. It was obtained much as the line of metal except that the trunnions were brought into a vertical instead of a horizontal position. As well the line on the right trunnion was bisected with a vertical line, so that on ship board it was possible with the aid of a plumb line to ascertain when the axis of the gun was horizontal. It is not clear but these marks may have been only for naval guns, since the centre of metal on the base ring was used with a wooden side tangent scale, which was exclusively a naval sight.[24]

While the tangent scale seems to have been used for pointing field pieces from at least the late 1790s, it was not immediately adopted either for siege or garrison service or in the Royal Navy where the gun continued to be laid by the line of metal and the quarter sights. The latter method may have been adequate on land, but on a rolling ship the necessity of directing the gun over the top and then of determining the elevation at the side was extremely awkward. Adverse encounters with American frigates during the War of 1812 convinced the Lords of the Admiralty, when hostilities had ceased, to attempt to discover efficient sights and elevating devices. In 1817 they asked Sir William Congreve, the younger, to consider the problem.[25]

Although Congreve collected and made models of various kinds of sights, his immediate inspiration was a straight-edge sight used by the Americans during the War of 1812. It was a simple grooved piece of wood fixed to the upper surface of the gun, parallel to its axis, which enabled the gunner to direct the piece at point blank, but it had no means of elevation.[26] Congreve improved on its design by providing the means of elevation and equipping it with a tube or rings to keep the eye down to the proper level when the gun was being laid. After considering the various sights, their Lordships agreed with Congreve that some form of the straight-edge sight was appropriate to naval gunnery, and they directed that tests be made with different models on board H.M.S. Liffey. These were carried out from January to June 1819.

Congreve designed three different lengths of sights, for guns or carronades, based on the straight-edge principle. The straight-edge, which was grooved, could be used as an open sight, or it could be fitted either with a tube with cross wires or, at each end, with a ring with cross wire. The longest was attached by a foot in front of the second reinforce ring and by a shackle to the vent patch, using one of the screws securing the lock. It was jointed at the foot and could be raised to various elevations from point blank to 5 degrees by fixing the shackle into a graduated scale of holes drilled into it. A shorter sight, which was attached to the vent patch and at the first reinforce ring, was elevated slightly differently, by legs of unequal length attached at each end, working somewhat like parallel rulers. The shortest sight, which was also elevated by this method, was fitted to the vent patch on the side opposite to the lock. Congreve designed an addition which was added to the longest sight in response to a suggestion that more accuracy could be achieved if the sight extended to the muzzle. Each sight was so calculated that it could be attached to 32-, 24-, or 18-pounders.

The practice on board H.M.S. Liffey was very successful. Captain Duncan, the officer in charge, commented: "... I do not think there can be better sights than those fitted on our gun" and "... I am perfectly satisfied as to the utility of the Sights." In November 1819 a joint committee of naval and field officers, persuaded of the efficacy of Congreve's sights, recommended their adoption for guns and carronades in the Royal Navy. Certain minor alterations in the manner of attaching and elevating the sights were made, but the principle was essentially Congreve's of sighting through two rings along a grooved straight-edge.

The sight's initial success was short lived; by 1827 the Royal Navy was dissatisfied with them and, in that year, withdrew them from service. The sights were undoubtedly ingeniously designed, in the words of one writer, "... of delicate construction, fitted, with mathematical and mechanical nicety, to minute differences of elevation...," but because of their standing so high above the gun, they were liable to damage from falling rigging or other debris during action or by the working of tackles and sheets when the ship was manouvering. If a strong breeze was blowing, they could not be used from the lee side for high elevations because the lowness of the ports blocked a view of the target. If the ship was in quick motion in rough seas, because the sights were closed it was extremely difficult to anticipate the arrival of the target in the rings and, thus, the proper moment of firing; open sights were found much more advantageous. Finally, Congreve's sights were expensive to manufacture.[27]

In 1828 Lieutenant T.S. Beauchant, R.M.A., published a book entitled The Naval Gunner in which he discussed, among other topics, the laying of guns.[28] Interestingly, he made no mention of Congreve's sights, which may indicate that they had fallen into disuse a number of years before the navy withdrew them from service in 1827. Rather, he described two tangent scales. One, which might be termed a dispart-tangent, set on the gun in front of the second reinforce ring and the other, for higher elevations, set about 9 inches in front of the breech. It is not clear from Beauchant's description whether he was proposing new sights or he was writing about existing ones. There are at the Rotunda, Woolwich, two brass tangent scales for the 24-pounder of 9 feet which are very similar to Beauchant's dispart-tangent scale (Fig. 240).[29] His sights may have been in use in the 1820s before the generally accepted Millar sights were adopted about 1830.

The dispart-tangent sight, which was set on the gun just in front of the second reinforce ring, allowed for elevations from point blank to the line of metal. A vertical slit in it was calibrated in quarter degrees, and a movable guide, which was secured by a screw, was raised or lowered to the desired degrees of elevation. The aim was taken by lining up the sight on the base ring, the movable guide, and the target. For elevations above the line of metal a second tangent scale was necessary, fixed to the gun 9 inches from the breech. It was of a similar design to the dispart-tangent sight, but longer, calibrated from the line of metal to 4-1/2 degrees. The aim was taken by lining up the movable guide, the sight on the muzzle swell, and the target. The long scale was probably made of wood, while the dispart-tangent sight was of metal.[30]

Without a dispart sight the tangent scale could not be used to lay a gun between the line of metal or dispart angle and point blank; for those elevations the quarter sights were utilized, a method which was very awkward, especially at sea. Beauchant's sights solved this problem, but they were not adopted (at least not for long). Rather in 1829, William Millar, Inspector-General of Artillery, devised sights which were used, first in the naval and then in the land service, until the end of the smoothbore era.[31] He attached a pointed gun-metal dispart sight to the second reinforce

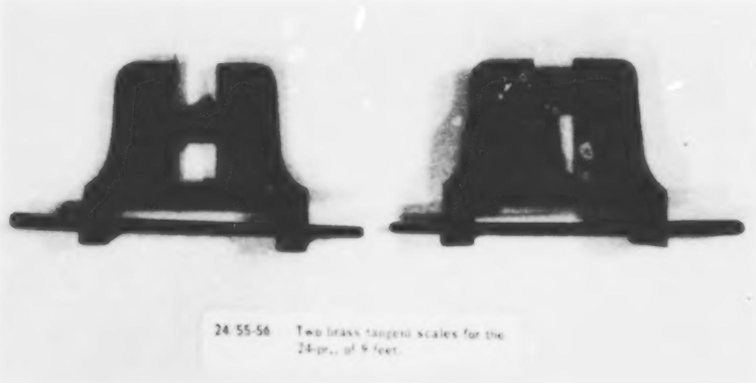


Figure 240. Two Brass Tangent Scales for the 24-pdr. of 9 feet (rear and front). (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXIV/55-6.)

ring of the gun or, if there was no ring, at the end of the second reinforce, and a gun-metal block, in which a brass tangent scale could slide, to the breech (Figs. 241 and 242). A piece of lead, not less than 1/8 inch thick, was placed underneath both the dispart sight and the block to prevent the fixing screws from snapping off when the gun was fired. These were hexagonal headed for all blocks for Blomefield guns and for all fore sights, but round headed for all other blocks. The former were removed with a wrench, the latter with a screw driver. (When the sights were removed, preserving screws were inserted into the screw holes.)

Eventually there were five different shapes of blocks — for the 8- and 10-inch guns; the 68-pounders; the 56-, 42-, and 32-pounders; all Blomefield guns; and the 32-pounder of 25 hundredweight.[32] The tangent scale, which fitted into the block and was secured by a thumb-screw, was a brass rod, calibrated in quarters from point blank to a maximum of 5 degrees.[33] The extent of the calibration depended on the clearance angle of the guns above which the scale could not be used. Its upper end was shaped like an arrow-head, the point of which was notched. When wooden tangent scales were introduced, the block was fitted with two pins on which the wooden scale rested.[34]

Millar's sights were initially designed for the Naval Service, but the advent of steam driven warships impressed on the coast artillery their utility in laying a gun quickly when firing at a rapidly moving target. Late in 1845 this view was forcefully presented by a Captain Wilford, R.A., in a paper read before the Royal Artillery Institution, and in 1846 or 1847 Millar's sights were adopted in the land service.[35]

Toward the end of the 1850s, the Royal Navy adopted a hexagonal-shaped tangent scale made of brass tubing. The scale of degrees was marked on one side, and the ranges in yards for shot and shell with different charges were marked on the others. All scales were not marked in precisely the same way, but in accordance with the following principle:

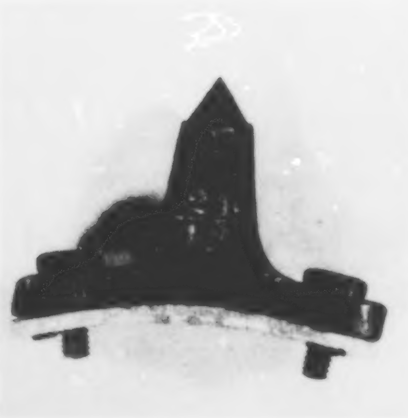


Figure 241. Millar's Dispart Sight. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXIV/43.)

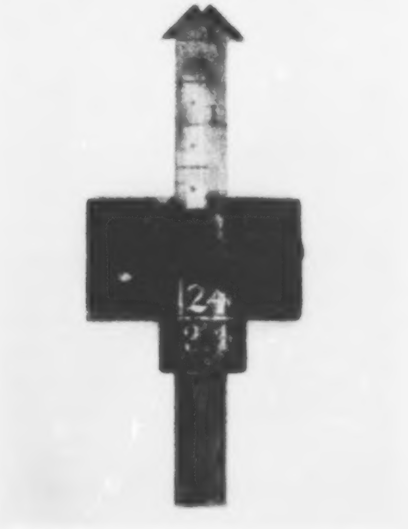


Figure 242. Millar's Tangent Scale for 32-pounder, 58 hundredweight, 9-1/2 feet. (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXIV/34.)

O	degrees	
F	yards with full charge	for shot
D	yards with distant charge	
R	yards with reduced charge	
SF	yards with full charge	for shell
SR	yards with distant charge	

The form of the scale and the method of making it were introduced by Admiral Sir Thomas Maitland, probably sometime between 1857 and 1859.[36]

Because the tangent scale and dispart sight could not be used beyond the angle of clearance, above which the muzzle obscured the target, a wooden tangent scale, made of walnut with brass fittings, called No. 1, was issued to the land service for elevations from the angle of clearance to 8 degrees (Fig. 243). The degrees above the angle of clearance were calculated using the long radius, that is, from the muzzle swell to the scale; opposite them the corresponding ranges were marked in yards. A slot ran down the middle of the scale along which a brass sight could be moved and secured by a screw at the appropriate elevation. The degrees below the angle of clearance (calculated, as on the brass scale, using the short radius) and the corresponding ranges were also marked on the wooden scale beneath the slot.

The base of the wooden scale, to which a brass plate was attached to prevent its splitting, was designed to fit over the block of the brass scale (Fig. 244). A brass staple or fixture was attached to the back into which the head of the brass scale fitted. Thus, when the wooden scale was to be attached to the gun, the brass scale was raised, its head inserted into the brass staple, and the wooden scale was pressed down until it rested on the block, when the thumb screw was tightened to secure the brass scale. This sight was introduced by Colonel Hardinge, R.A., at almost the same time as Millar's sights were adopted.

Another wooden scale, No. 2, also made of walnut, was issued to guns which were not fitted with Millar's sights. Similarly marked to No. 1 scale, it was calibrated, using the long radius, from the line of metal to 8 degrees. Its base, to which a brass plate was attached, was curved to fit the base ring, and a piece of brass projected down to fit into the notch thereon. It was held by hand.[37]

In the naval service, pivot and shell guns required elevations greater than the angle of clearance. Instead of the wooden scales of the land service, the navy substituted a long metal tangent scale, calibrated for the long radius, for the short scale. Because of the short distance between the block and the breeching loop of the gun (this varied depending on the design of the gun), up to four scales might be required to give elevations up to 10 degrees (sometimes 11 degrees), each taking up where the last left off. In 1849, Noble, a student at the Royal Military Academy, indicated that the long scales were brass, but in 1860 Douglas wrote that they were wood because brass scales of great length tended to droop. Later authorities suggested that both materials were used. Their form and markings were the same as the shorter scales for which they were substituted. Broadside guns usually were supplied only with the short scale, but for every six guns one set of long scales giving elevations up to 10 degrees was issued.[38]

In addition elevation could be given on ship board by a wooden tangent scale, which was used when the elevation required was so great that the line of sight was blocked by the upper edge of the port hole. Graduated to give 12 degrees of elevation and 6 degrees of depression, it was held on one of the steps of the carriage bracket, and used in conjunction with the ship's pendulum that indicated the heel of the vessel.[39]

When the method of finding the lengths of degrees on a tangent scale was explained above, it was assumed that the scale was perpendicular to the axis of the piece. Millar's scale, however, was inclined at an angle of 14 degrees from the vertical; thus it was not truly a tangent scale, and a different formula was used to establish the length of each degree:[40]

Up to the clearance angle, that is for the metal scale

$$x = r \frac{\sin b}{\sin (90 + a - b)}$$

Above the clearance angle, that is for the wooden scales

$$x = R \frac{\sin (b - c)}{\sin (90 + a - b)}$$

where a = angle of inclination of tangent scale from vertical
b = given angle of elevation
c = angle of dispart
r = short radius
R = long radius
x = length of tangent scale required.

(The value of sin can be obtained from trigonometrical tables.)

A practical method of calibrating a tangent scale, which the Ordnance adopted, was to use a radius board. This was an accurately planed wooden table about 12-1/4 feet long and about 3-1/4 feet broad at one end and 1-1/2 feet broad at the other. Drawing paper was pasted to it. From a point at the small end of the table an arc of 14 degrees with a radius of 12 feet and one of 20 degrees with a radius of 6 feet were drawn. They were accurately divided into degrees and radii were drawn to these divisions. The bottom radius was divided into tenths of inches. A line drawn from the bottom radius at any point on it, at a right angle or at any required inclination to it, will represent the tangent scale for that radius and inclination and will be accurately divided into degrees by the various radii. The lengths can then be transferred to the tangent scale.[41]

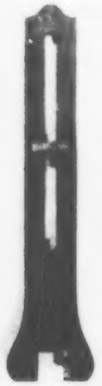


Figure 243. Wooden Tangent Scale, No. 1, for 32-pounder, 58 hundredweight, 9-1/2 feet (front view). (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXIV/35.)

Figure 244. Wooden Tangent Scale, No. 1, for 32-pounder, 58 hundredweight, 9-1/2 feet (rear view). (The Royal Artillery Institution, Woolwich, U.K., The Rotunda, XXIV/35.)

SUMMARY

This book provides a great amount of information on the construction of British smooth-bore ordnance, carriages, platforms, projectiles, and certain ancilliary equipment to enable Environment Canada — Parks to undertake reconstruction of them. As well, it has made available material that will be of use to Parks interpreters in explaining the nature and function of artillery within the military sites. It is not claimed that all questions have been answered, but it is felt that sufficient information has been provided to enable Parks to attempt reconstructions with some degree of confidence in their accuracy, even when examples of the weapon or carriage are no longer extant.

It is worth noting that during the study, I was asked to provide information to the Atlantic, Quebec, and Ontario regional offices of Parks on the production of ordnance and accoutrements. The experience gained therefrom was valuable and serves to highlight the real or potential limitations of a general work such as this. For example, historical requisitions for material to repair the traversing platform and carriage at Fort Wellington provided partial dimensions to reproduce these items, but when they were compared with what was known of the standard Royal Artillery platform of the period, there was a variance. Seemingly the Royal Artillery at Fort Wellington had made local adaptations for reasons that remain obscure. The resulting platform that was built was the conventional platform as modified by the knowledge gained from the repair requisitions. At Fort Henry, historic knowledge was useful to complete and verify as-found drawings of an existing weapon, a rifled 7-inch Armstrong gun. Also, the carriage and platform there was a reconstruction which, when compared with historic drawings turned out to be inaccurate in many respects; consequently the reconstruction was based mainly on historical material. In the case of Coteau-du-Lac where almost all details of the platform and carriage that had been there in the 1820s were lacking, the work of reconstruction was based on contemporary drawings made by Royal Artillery officers in England. Lacking local detail it was necessary to revert to standard.

Any study of this nature will be incomplete, but it is hoped that as reconstruction work is carried out new knowledge which comes to light will be made available to supplement this work. It is also hoped that any errors discovered will also be communicated to me so that the study can be as accurate as possible.

APPENDIX

The following appendices detail the dimensions and changes thereof for British smooth-bore ordnance during the period circa 1710-1860.

The original language and spelling has been retained generally, but in some cases the original documents have been adapted or modified for clarity or to enable their more convenient reproduction on modern word processing equipment.

In particular the tables from the 1844 edition of Morton Spearman, The British Gunner, in which measurements were given in feet and decimals of feet, were converted to feet and inches to make comparisons with other sources easier.

Appendix A. General Statement of the Regulations and Practice of the Inspector of Artillery's Department in Examining, Proving and Receiving of Iron Ordnance Supplied by Contractors for His Majesty's Service and that of the East India Company.

Note. The limitations in construction are given in a Table which is hung up in the Inspector's office and to which all Contractors have access.

The limits for Ordnance for the King's and the India Company's Services are within narrower bounds than those for Merchants: And it is not the practice to submit the latter Guns to the Water Proof unless it may be asked for.

Proof Charges for Iron Guns

	Powder	
32pr	21 1/2 lbs.	
24	18	One round Shot and two
18	15	junk wads are used
12	12	each round.
9	9	
6	6	

Note: The above charges apply to Iron Guns of the regular Fabric: but for those of a lighter nature, double the Service Charge is generally used for proof.

For Carronades

	Powder	
68pr	13lbs	
42	9	One round shot and one
32	8	junk wad are used
24	6	each round.
18	4	
12	3	
6	1 1/2	

Weight of Junk Wads

	lbs	oz.	
68 pr	4	11	
42	2	14	
32	2	4	
24	1	12	number as
18	1	6	above
12	1	1	
9	0	12	
6	0	9	

1st On the Ordnance being received from the Contractors, they are drawn to a convenient place for Examination; which in the first instance is confined to the External figure and dimensions, and their being free from outward flaws and honey-combed defects: After which their Cylinders are visited by very accurate Instruments, and, if found Sufficiently correct, and in the true axis of the piece (not exceeding certain small limits) they are taken to the Proof Ground.

2nd The Ordnance are then laid horizontally, and fired one round, loaded in accordance with the Table in the margin; after which they are carefully seached twice, and should their bores be found free from flaws or holes, they are (as soon after as convenient: sometimes the same day but generally the day following) subjected to a similar proof and searching.

Holes or flaws discovered after the first round render, of course, further proof unnecessary.

Holes in the bore which condemn the piece are

In the Charging		
Cylinder	1/5	of an
In the Chase	1/4	inch

Further Trial Charges for Guns

	Powder	
32	14 lbs.	
24	11	Two round Shot and two Junk wads used each round.
18	9	
12	6	
9	4 1/2	
6	3	

Note: The Inspector has lately preferred (with the Concurrence of the Contractor) in the Event of any Gun bursting, the putting the whole of those laid with the burst Gun, to a third Proof with the same charge, as the first and Second. And should any failure take place in this third Proof, the whole will be condemned: But as yet there is no authority from the Board for this Change.

3rd Should one Gun in ten burst in both the above rounds, the whole number laid are rejected, and are not to be subjected to any farther Trial.

4th Should a smaller proportion than one in ten fail, and the Inspector be generally satisfied with the strength and quality of the metal, then a piece is selected on each side the running number of that which burst to be put to further Trial, by firing each twenty rounds with the Charge given in the opposite Table; And should either of them fail by this Test of ascertaining their strength, it is at the Inspectors sic discretion to reject the whole, unless the Founder can give such substantial reasons as may induce him to extend this Trial to those which have been cast under different Circumstances; as the failure by their firings is a strong evidence against the quality, or evincing bad management of the metal in the Furnace.

5th Should the whole number of pieces resist the Proofs they have been submitted to, so as to satisfy the Inspector's judgement of their Strength, they are taken from the butt, and subjected to the water Proof, which is applied, by forcing Water into their Cylinders, by means of a powerful Engine; and it will be in the Inspector's discretion to condemn Such piece as has its mass penetrated through with the water.

Lastly. The Guns are well washed out, and conveniently laid up so as to admit the Sun's rays being reflected from a Mirror into their bores, to discover whether any Flaws or Holes may have escaped the former Searchings, which are perceptible from the water which may have been forced into the Open parts, leaving them in a discoloured state, and thus leading to their detection: And, during the whole proceedings the greatest possible care is taken to find that no defects have been concealed by Screws, Plugs or Hammering up of Holes or Flaws by the Founder previous to their delivery: as such measures if discovered in any of the Guns would lead to the rejection of the whole number sent for Proof.

The Guns after proof and examinations are received as being fit for His Majesty's Service and marked; and such as may be condemned are mutilated and returned to the Contractors.

With regard to the Strength of the Powder used & the Elevation of the Piece It may be observed that the Powder is large Grain of the very best quality: The Guns are laid on the ground without Carriages, and fired nearly horizontal into the Butt.

Proof Charges of Powder
for Iron Mortars

	Sea		Land
	lbs.	oz.	lbs.
13 In.	20	11	9
10	9	8	4
8			2

The foregoing Instructions apply to Iron Guns only. Mortars and Howitzers are examined and proved upon the same principle; the former, however, are fired with their Chambers full of Powder, and a Solid Ball; upon their own beds; generally at a high Angle, (about 75°) though of late from the almost total impossibility of getting a Safe Range upon the River, they have been laid as Guns and fired into the Butt.

Proof Charges of Powder
for Gomer Iron Howitzers.

10 Inch.	12 lbs.
8	8

Iron Gomer Howitzers are proved in the same manner with the Charges given in Margin; but with a Shell.

Source: Royal Artillery Institution (RAI), General Statement of the Regulations and Practice of the Inspector of Artillery's Department..., circa 1785.

Appendix B. Use of Desaguliers' Instruments

The first instrument, called Desagulier's [sic], is employed, to ascertain whether the bore is correctly situated, that is to say, if its axis is identical with that of the piece, and also to test the smoothness and regularity of the bore.

This instrument is of the following construction. Two long iron bars are connected together, so that they can be moved outwards or inwards on the principle of parallel rulers, and are opened and closed by a screw at one end; at the same end of the bars there is a framework of brass, on which slide two brass arms, these being strictly at right angles to the bars, and they can be moved in or out by means of small pinions. At the ends of these arms are two others placed at right angles to them, and consequently parallel to the long bars; upon each of these last arms are fixed two small brackets of brass, each having a fine notch cut in it, so that the line joining the notches on either side shall be strictly parallel to the long bars.

The application of the instrument is as follows. The iron bars are inserted into the bore of the piece, and held in the axis by means of *heights* fixed underneath; the bars are opened by means of the screw until they touch the surface of the bore. A silk thread being held at the notch *A*, at the extremity of one of the arms, the other end of it is placed against the base ring, or in a notch in a plate resting against the base ring, *C*; the arm is thus moved in or out by the pinion until the thread falls into the other notch *B*. This being done, the distance *BD*, of the thread from the edge of the nearest long bar outside the muzzle is measured, and this must manifestly equal the thickness of metal *CE*, at that part of the piece where the end of the silk is placed. The same is done on the other side of the piece, and should the two measurements agree, it is evident that the axis of the bore corresponds with that of the gun as regards one plane.

Whilst the above apparatus is in the bore another part of the instrument is placed in, called the *index rod*, consisting of a long rod having a powerful spring at the end which first enters the bore. A small arm carrying a friction wheel is fitted on to the end of the spring, and is connected by a bent lever to another thin rod, which passes down the length of the first, and is attached to a hand working over an index plate fixed to the end of the rod which projects from the muzzle; any movement of the friction wheel, which touches one side of the bore, is multiplied on the divisions of the index plate, so that a very slight compression of the spring is clearly shown, and any irregularity in the surface of the bore on this side easily detected; the distance of the irregularity from the face of the muzzle can be readily seem by the divisions on the rod.

Both sides of the bore are examined with the above instrument when the trunnions are horizontal, and also when they are vertical. Before the bars are removed the diameter of the bore is measured across them by means of small sliding callipers.

Source: Charles H. Owen, *Rough Notes on the Manufacture of Ordnance, Carriages, and Ammunition, prepared for the use of the Gentlemen Cadets of the R.M. Academy* (Woolwich: Royal Artillery Institution, 1867), pp. 23-24.

Appendix C. Powder for Proof of Ordnance, circa 1720-1820[1]

Guns					Brass[2]							
	Heavy				Medium				Light			
Cal.	Proof		Service		Proof		Service		Proof		Service	
	Lb.	oz.	Lb.	oz.	Lb.	oz.	Lb.	oz.	Lb.	oz.	Lb.	oz.
42 pdr.	31	8	21									
32	26	12	16									
24	21		12		18		9		10		5	
18	18		9									
12	12		6		9		4		6		3	
9	9		4	8								
6	6		3		6		3or 2	8	3		1	8
4	4		2									
3	3		1	8	3		1	8	1	8		12
2	2		1									
1 1/2	1	8		12								
1	1			8								
1/2		8		4								

					Iron								
	Heavy				Medium				Light				
Cal.	Proof		Service		Proof		Service		Proof			Service	
	Lb.	oz.	Lb.	oz.	Lb.	oz.	Lb.	oz.	Lb.	oz.	dr.	Lb.	oz.
43 pr.	25		17						22	3	8 8/9	14	
32	21	8	14						19	1	11 4/9	10	10
24	18		11						16			8	
18	15		9						13	5	5 1/3	6	
12	12		6						10	10	10 1/4	4	
9	9		4	8					8	8		3	
6	6		3		4	0	2	0	5	5	5 1/2	2	
4	4		2						3	8	14 2/9	1	10
3	3		1	8					2	10	10 2/3	1	
2	2		1						1	12	7 1/9		10
1 1/2	1	8		12					1	5	5 1/3		7
1	1	0		8						14	3 5/9		4 1/2
1/2		8		4						7	1 2/9		2 1/4

Appendix C. Powder for Proof of Ordnance...(cont.)

Carronades

	Proof		Service		
	Lb.	oz.	Lb.	oz.	
68 pdr.	13		6		
42 pdr.	9		4	8	
32 pdr.	8		4		
24 pdr.	6		3		
18 pdr.	4		2		
12 pdr.	3		1	8	
9 pdr.	2			12	Merchants'[3]
6 pdr.	1	8		8	
3 pdr.	1			4	

Howitzers

	Brass		Iron	
	Lb.	oz.	Lb.	oz.
10 inch	7		12	
8 inch	3	8	8	
5 1/2 inch	1			
4 2/5 inch		8		

Brass and Iron Mortars, Land and Sea Service

	Brass		Iron[5]	
	Lb.	oz.	Lb.	oz.
13 inch S.S.	30		20	11
10 inch S.S.	12	8[4]	9	8
13 inch L.S.	9	8 to 10 lb.	9	
10 inch L.S.	3	14 to 4 lb.	4	
8 inch L.S.	2		2	
5 1/2 inch L.S.		9		
4 2/5 inch L.S.		4 1/2		

1 These proof tables 1720-1820 have been compiled from the following sources. RAI, Thomas James, His Book of Artillery... (G3n/1a), p. 27, "Weight and Value of Brass and Iron Cannon according to their different Lengths: With the Quantity of Powder required for Proof, Service, Saluting and Scaling, according to the First and Second Regulation" (circa 1725); RAI, Practice Book, 1760, "General Borgard's Table of Powder allow'd for Iron and Brass Guns," unpaginated; RAI, Samuel Glegg, Notes on Artillery, (circa 1752), "Diameters of Guns, Shot Gauges &c," p. 134; RAI, S.P. Adye, The Artillery Officer's Vade Mecum... (New York, 1766), Vol. I, pp. 20-1; RAI, Artillery Experiments, 1770-1; 1773, "Weight of Powder for Proof Service and Scaling of Brass and Iron Ordnances," unpaginated; Pamphlet, Vol. 19, T. Fortune, The Artillerist's Companion... (London, 1778), p. 21; George Smith, A Universal Dictionary... (Ottawa, 1970 reprint), pp. 211-12; RAI, Thomas Walton, Gunnery Tables 1780-1792, "Weight of Powder for Proof Service & Scaling of Brass & Iron Ordnance," unpaginated; RAI, Artillery Practice (circa 1780), "Proof Table for Mortars and Howitzers," p. 3, "Weight of Powder for Proof, Service, Saluting, and Scaling Iron Guns and Carronades," p. 11; Second Part, "Weight of Powder for Proof Service & Scaling Brass & Iron Ordnance," p. 89; G3n/35, Untitled MS, (circa 1798), "Weight of Powder for Proof, Service and Scaling of Brass and Iron Ordnance. 1797," unpaginated; RAI, Richard Bogue, Exercise & Manoeuvres for Light 6 Pounders (circa 1800), "Weight of Powder for Proof, Service, Saluting and Scaling Iron Guns & Carronades," p. 135; RAI, Oliver Fry, Tables of Ranges, Weights, &c. of Ordnance (circa 1800), "Proportion of powder for the undermentioned Uses Also the weight of Shells," unpaginated; R.W. Adye (1801), The Little Bombardier, and Pocket Gunner (London), p. 178 and (1813), p. 294.

2 RAI, Glegg, op. cit., p. 134. Glegg is the first to include light and medium brass guns. His figures for the following calibres are at variance with later tables:

	Proof	Service
	Lb.	Lb.
light 24	12	6 or5
med. 12	8	4 or3
med. 6	4	2

Adye (1801), op. cit., p. 178, (1813), op. cit., p. 294, makes the following notation: "The brass ordnance have not however been proved of late with such heavy charges, but with the following:

3 - prs. light, 3 times, with 1 lb. each round.
6 - prs. light, 3 times, with 2 lbs. each.
12 - prs. light, 2 times, with 4 lbs. each.
12 - prs. med. 2 times, with 5 lbs. each."

RAI, T.R. Mould, "Observations on a Course of Instruction in Artillery," pp. 133-8, in 1825 noted some changes in the proof of brass ordnance:

		Lb.
Heavy	12	6
Med.	12	5
	9	3 1/2
Heavy	6	3
Light	6	2
Heavy	3	1 1/2
Light	3	1

3 RAI, Untitled MS, (circa 1798) is the only source to include 9-, 6-, and 3-pounders.

4 RAI, Fortune, op. cit., p. 21; Smith, op. cit., p. 212; RAI, Fry, op. cit., unpaginated, give 10 lb. 4 oz. as the proof charge of the 10-inch S.S. brass mortar.

5. The powder charge for proof of iron mortars is taken from RAI, General Statement of the Regulations and Practice of the Inspector of Artillery's Department..., circa 1785.

Appendix D. Powder for Proof Charge, *circa* 1820-70.[1]

CAST IRON GUNS

	Length		Weight	Service		Proof	
	Ft.	In.	Cwt.	Lb.	Oz.	Lb.	Oz.
12 inch	8	4	90	12		18	
10 inch	9	4	87	12		20	
	9	4	85	12		18	
8 inch	9		65	10		20	
	8	10	60	9		18	
	8	6	60	9		18	
	8		52	8		16	
	6	8	50	8		14	
68 pdr.	10	10	112	20		30	
	10		95	16		28	
	9	6	87	14		25	
56 pdr.	11		98	16		28	
	10		85	14		25	
42 pdr.	10		84	14		25	
	10		75	12		25	
	9	6	67	10	8	23	
32 pdr.	9	7	64	10		21	8
	9	6	58	10		18	
	9	6	56	10		21	8
bored-up 24	9	0	46	6		12	
	8	0	48-50	8		21	8
Monk's A	9	0	50	8		18	
Monk's B	8	6	45	7		16	
Monk's C	8	0	42	6		14	
bored-up 18	8	0	41	6		18	
Congreve's, bored-up 24	7	6	40	6		12	
bored-up 24	7	6	39	6		12	
bored-up 24	6	6	32	5		10	
bored-up 18	6	0	25	4		9	
	5	4	25	4		9	
24 pdr.	9	6	50	8		18	
	9	0	48	8		18	
bored-up 18	8	0	37				
Congreve's	7	6	41	8		15	
	6	6	33	6		12	
bored-up 12	6	0	20	3		6	

Appendix D. Powder for Proof Charge...

CAST IRON GUNS (continued)

		Length		Weight	Service		Proof	
		Ft.	In.	Cwt.	Lb.	Oz.	Lb.	Oz.
18 pdr.		9	0	42	6		15	
		8	0	38	6		15	
	bored-up 9	7	0	22	3		7	
	bored-up 12	6	0	20	3		7	
	bored-up 9	5	6	15	2		5	
12 pdr.		9	0	34	4		12	
		8	6	33	4		12	
		7	6	29 1/2	4		12	
		6	0	21	4		10	
9 pdr.		8	6	28 1/2	3		9	
		7	6	26	3		9	
		7	0	25	3		9	
		5	6	18	3		8	
6 pdr.		8	6	23	2		6	
		8	0	22				
		7	6	21	2		6	
		7	0	20	2		6	
		6	6	18				
		6	0	17	2		6	
		5	11	11				

BRASS GUNS

		Length		Weight	Service		Proof	
		Ft.	In.	Cwt.	Lb.	Oz.	Lb.	Oz.
12 pdr.	medium	6	6.6	17 1/2	4		5	
	light	5		12	3		3	
9 pdr.		5	11.4	13 1/2	2	8	3	8
6 pdr.	long	7		12	2		3	
	heavy	5	2.356	8 3/4	2		3	
	light	5		6	1	8	2	
3 pdr.	long	6	0 1/2	6	1		1	8
	light	4		3				
	colonial	4		3		12	1	
	mountain	3		2 1/4		10	1	
1 pdr.		5		2 1/2		6	12	

Appendix D. Powder for Proof Charge...

CAST IRON HOWITZERS

10 inch	5		42	7		12	
8 inch	4		22	4		8	
5 1/2 inch or 24 pdr.	3	4.76	8 1/2	2	8	6	

BRASS HOWITZERS

	Length	Weight	Service	Proof			
	Ft.	In.	Cwt.	Lb.	Oz.	Lb.	Oz.
32 pdr.	5	3	17 1/2	3		4	
24 pdr.	4	8.6	13	2	8	2	8
12 pdr.	3	9.2	6 1/2	1	4	1	4
5 1/2 inch	2	9	10	2		3	
4 2/5 inch	1	10.6	2 1/2		8	1	

CAST IRON MORTARS*

13 inch S.S.	4	4.8	100	20		20	11
10 inch S.S.	3	9.6	52	9	8	9	8
13 inch L.S.	3	3.6	36	9		9	
10 inch L.S.	2	7.5	18	4		4	
10 inch L.S.	2	4.1	17	4		4	
8 inch L.S.	2	1.2	9	2		2	
8 inch L.S.	1	10.5	6 1/2	2		2	

BRASS MORTARS

10 inch	2	3	12 1/4			4	
8 inch	1	9	6 1/2			2	
5 1/2 inch	1	3.1	1 1/4		8		8
4 2/5 inch	1	0.7	1		4		5

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1 These tables were compiled from a number of sources, in which there were some minor variations of no great significance. DND, Fitzhugh, "A Course of Practical Artillery," (Woolwich, 1845), p. 115; F.A. Griffiths, The Artillerist's Manual and British Soldier's Compendium (Woolwich: E. Jones, 1847), pp. 69-70; Royal Engineers, Aide-Mémoire to the Military Sciences, (London, 1853), Vol. I, pp. 60-3; E.M. Boxer, Diagrams of Guns referred to in Treatise on Artilery prepared for the use of the Royal Military Academy, Section 2. - Part II (London: Eyre and Spottiswoode, 1853), passim; John F. Owen and Morton Porter, Treatise on the Construction and Manufacture of Ordnance... (Reprint: London, 1881), p. 525.

* For mortars, service charge means maximum charge.

Appendix E. Particular Dimentions of all the Parts of an Iron 6 Pounder Cannon of Eight Foot Long According to the New Proportion given by Coll. Borgard in the year 1716.

		Caliber	Inches
Length			
A T	Totall Length	25 15/16	96.00
A G	Fore Part	12 31/32	48.00
G N	Middle Do	5 3/16	19.20
N T	Hind Part	7 25/32	28.80
A D	Head with Astragall	3 7/16	12.75
A R	Cylinder or Bore	24 15/16	92.30
R T	Resistance	1	3.70
T X	Cascable whole length	2	7.40
W X	Neck and Button	1 19/64	4.81
L T	Tronion's Center from the Base Ring	11 1/8	41.14
I K	Do Length	1	3.70
Moulding's Breadth with Freeze			
A B	Muzle	5/16	1.12
C D,E F,P Q	Astragall	13/64	0.75
G H	Second Reinforce Ring	41/64	2.37
N O	First Reinforce Ring	41/64	2.37
S T	Base Ring	23/32	2.62
T V	First Cascable with stave	25/64	1.43
V W	Second Cascable with stave	17/64	1.00
Q S	Plain Freeze	1	3.70
F G	Second Reinforce Ring Do.	3/4	2.77
Thickness of Metall		1 1/4	4.62
l m	Over Vent	1 3/16	4.39
n o	Behind the first Reinforce	1 1/16	3.93
r s	Before	1	3.70
t v	Behind the second Reinforce	7/8	3.24
y z	Before	1/2	1.85
3 4	Muzle		
Moulding's greatest height above the Metall		7/32	0.80
i k	Baze Ring	3/32	0.37
p q	First Reinforce Ring	3/32	0.37
w x	Second Reinforce Ring	31/64	1.80
1 2	Head		
Semi-Diameter of the			
g h	First Cascable Stave	1 7/32	4.50
e f	Second Cascable Stave	23/32	2.65
c d	Neck	1/2	1.85
a b	Button	39/64	2.24
L M	Tronion	1/2	1.85

Source: Slightly adapted from RAI, Borgard, Artillery Tables, No. 30.
Refer to Fig. 56.

Appendix F. A Table for Surveying Iron Cannon in the Severall Parts According to the Regulation by Coll Borgard in the year 1716.

(The first part of this table, "Length" and "Moulding's Breadth with Freeze," duplicates the parts and dimensions in inches of the previous table, and is consequently omitted.)

Diameter		Inches
8 9	Bore	3.70
7 10	Muzle Stave	7.80
5 6	Head	11.12
3 4	Behind the head Astragall	8.12
1 2	Before The Second Reinforce Ring	10.17
y z	Over The Second Reinforce Ring	11.87
w x	Behind The Second Reinforce Ring	11.10
K M	Tronion	3.70
r s	Before The First Reinforce Ring	11.56
p q	Over The First Reinforce Ring	13.25
n o	Behind The First Reinforce Ring	12.49
l m	Vent	12.95
i k	Base Ring	14.57
g h	First Cascable Stave	9.00
e f	Second Cascable Stave	5.30
c d	Button Neck	3.70
a b	Button	4.48

Source: Slightly adapted from RAI, Borgard, Artillery Tables, No. 30.
Refer to Fig. 56.

Appendix G. Dimensions of Brass Guns According to the Mensuration in the Year 1743.

Caliber [Pounder]	32	24	18	12	6	3	1 1/2
Total Length [feet]	10.0	9.5	9.5	9.0	8.0	7.0	6.0
First Reinforce	in	in	in	in	in	in	in
Length	33.2	31.6	31.6	29.5	26.6	23.3	20.0
G: Diameter	18.3	17.8	16.6	13.8	12.5	10.2	7.6
Least Diameter	17.6	16.7	15.6	13.1	11.3	9.7	7.2
Second Reinforce							
Length	24.0	20.3	20.3	19.6	17.1	15.0	12.8
G: Diamr.	16.3	16.0	14.8	12.2	10.7	9.1	6.6
L: Diamr.	15.7	15.1	14.3	11.9	10.0	8.6	6.4
Chase							
G: Diamr.	14.3	14.2	13.2	10.8	9.1	7.8	6.1
L. Diamr.	12.2	11.7	11.5	9.3	7.8	6.5	5.4
Base Ring							
Breadth	1.3 [?]	1.5	1.5	1.5	1.2	1.1	0.8
Diamr.	21.0	19.2	18.2	15.3	13.6	11.5	8.7
Vent							
Field	5.5	4.4	3.6	3.2	2.6	2.4	2.2
Astragal	1.1	1.3	1.3	1.4	1.1	1.0	0.9
First Reinforce Ring							
Breadth	1.2	1.4	1.4	1.5	1.0	1.0	0.8
Diamr.	18.4	17.2	16.1	13.4	11.7	10.0	7.5
Ogee	1.4	1.7	1.7	1.8	1.3	1.2	1.1
Second Reinforce Ring							
Breadth	1.2	1.4	1.4	1.5	1.0	1.0	0.8
Diamr.	16.5	15.4	14.9	12.2	10.3	9.3	6.6
Ogee	1.4	1.7	1.7	1.4	1.3	1.2	1.1
Chace							
Girdle	4.0	4.4	4.4	3.0	2.5	2.0	1.4
Astragal	1.1	1.3	1.3	1.3	1.1	1.0	0.9
[Muzzle face] to the Muzzle Girdle	15.0	14.2	14.2	12.7	12.0	10.5	9.0
Muzzle							
Ring	11.9	11.4	11.0	9.2	7.8	6.5	5.3
Ogee	1.7	1.0	1.0	1.4	1.9	0.8	0.7
Diamr. Fillett	14.2	14.0	13.5	10.0	9.3	7.6	6.7
Swel Muzle							
Distance [from face]	2.2	1.5	1.5	1.4	1.2	1.0	0.8
Diameter	15.3	15.3	15.0	12.4	10.0	8.8	7.3
Trunnion from 2d. Reinforce Ring	2.9	0.4	1.2		0.6	0.4	2.5
Length of Cascable	12.2	11.0	10.0	9.2	7.0	5.4	4.4
To first Fillett	9.5	9.0	7.5	7.3	6.0	4.5	
Diameter	9.3	9.1	7.8	6.6	6.5		4.1
2d. Fillett Diamr.	14.8	17.8	16.5				
Weight of Metal [Cwt. Qr. Lb.]	55/2/7	51/1/12	48/1/0	29/0/0	19/0/0	11/0/0	5/3/24

RAI, Clegg, Notes on Artillery, *circa* 1752, pp. 115-16.

Appendix H. Dimensions of Iron Guns According to mensuration in the Year 1743.

Caliber [Pounder]	32	24	18	12	9	6	3	1 1/2
Total Length [feet]	9.5	9.5	9.0	9.0	8.5	7.0	6.5	4.5
[First Reinforce] inches								
Length	31.2	32.0	29.0	30.0	28.0	23.0	21.0	14.5
G. Diamr.	20.0	19.1	17.8	16.1	15.2	15.2	13.7	10.6
L. Diamr.	18.8	17.8	16.8	15.2	14.2	14.5	12.7	9.8
[Second Reinforce]								
Length	22.8	21.0	22.0	19.7	18.7	16.0	15.0	10.0
G. Diamr.	18.0	16.9	16.1	14.3	13.5	13.6		9.4
L. Diamr.	17.2	16.3	14.4	13.6	12.7	12.9		9.0
[Chase]								
G. Diamr.	16.2	15.4	14.6	12.0	11.9	12.0	10.5	8.3
L. Diamr.	13.8	12.7	11.7	9.8	9.6	9.3	8.4	6.8
[Base Ring]								
Breadth	2.1	1.9	2.0	1.6	1.8	1.6	1.7	1.1
Diamr.	21.8	20.8	19.4	17.9	16.9	16.9	15.3	11.5
Vent								
Field	4.9	4.4	4.0	0.3 ?	4.0	4.1	3.6	2.1
Astragal	1.5	1.4	1.3	1.3	1.2	1.3	1.2	0.8
[First Reinforce Ring]								
Breadth	1.2	1.2	1.1	1.2	1.0	1.0	1.0	0.8
Diamr.	19.5	18.4	17.3	15.7	14.6	15.0	13.2	10.2
[Second Reinforce Ring]								
Breadth	1.2	1.2	1.1	0.9	1.0	0.9	1.0	0.8
Diamr.	17.7	16.9	15.8	13.6	13.2	13.6	11.8	9.25
Chace Girdle	5.1	4.2	4.0	4.0	4.0	4.0	3.9	2.1
[Muzzle Swell?]								
Distance [from face]	2.0	2.0	2.0	2.0	1.7	1.7	1.7	1.5
Diamr.	17.7	16.6	15.5	13.8	13.0	13.0	11.3	9.0
Muzzle Astragal distance	17.0	16.0	15.5	14.0	13.2	13.5	11.5	
From 2d. Reinforce to Trunion	1.5	2.0	0.9	1.0	0.5	0.9	0.5	0.5
[Trunnions?]								
Diameter	6.0	5.7	4.3	5.0	4.0	4.3	3.7	3.0
Length	7.0	6.0	4.2	5.0	4.0	4.3	4.0	2.2
Diamr. Button	7.0	7.2	5.1	6.1	5.1	5.1	5.0	4.0
Weight of the Gun [Cwt.Qr.Lb.]	53/3/23	49/1/15	41/1/8	32/2/3	27/3/0	23/2/2	17/1/14	7/1/7

RAI, Clegg, Notes on Artillery, circa 1752, pp. 117-18.

Appendix I. Dimensions of Brass Battering Pieces of different Calibres (1766).

Nature of the Gun	Prs.	32	24	18	12	9	6	3	1 1/2
Total length of the Gun	Feet	9.5	9.5	9.5	9	9	8	7	6
First Reinforce	Inches								
Length		31.6	31.6	31.6	29.5	29.5	26.6	23.3	20.
Greatest Diameter		18.4	17.8	16.6	14.4	13.9	11.7	10.	7.5
Least Diameter		17.6	16.7	15.6	13.1	12.3	11.3	9.7	7.2
Second Reinforce									
Length		20.3	20.3	20.3	19.6	18.8	17.1	15.	12.8
Greatest Diameter		16.3	16.	14.8	12.2	11.	10.7	9.1	6.6
Least Diameter		15.7	15.1	14.3	11.9	10.6	10.	8.6	6.4
Chase									
Greatest Diameter		14.3	14.2	13.2	10.8	10.2	9.1	7.8	6.1
Least Diameter		12.2	11.7	11.5	9.3	9.	7.8	6.5	5.4
Base Ring									
Breadth		1.5	1.5	1.5	1.3	1.3	1.2	1.1	0.8
Diameter		21.	19.2	18.2	15.3	15.	13.6	11.5	8.7
Vent Field, Length		5.5	4.8	3.6	3.2	2.6	2.6	2.4	2.2
---- Astragal, breadth		1.3	1.3	1.3	1.2	1.2	1.1	1.	0.9
First Reinforce Ring									
Breadth		1.4	1.4	1.4	1.2	1.2	1.	1.	0.7
Diameter		18.4	17.2	16.1	14.4	13.9	11.7	10.	7.5
Second Reinforce Ring									
Breadth		1.4	1.4	1.4	1.2	1.2	1.	1.	0.7
Diameter		16.5	15.4	14.9	12.2	11.7	10.3	9.3	7.
Chase Girdle, length		4.4	4.4	4.4	3.	3.	2.5	2.	1.4
---- Astragal, breadth		1.3	1.3	1.3	1.2	1.2	1.1	1.	0.9
From the Chase Astragal to the Muzzle Astragal		28.2	28.2	28.2	26.7	26.5	26.5	24.5	23.
Muzzle Astragal, breadth		1.4	1.4	1.4	1.2	1.2	1.	1.	0.9
Swelling of Muzzle diameter		15.3	15.3	15.	12.4	11.2	10.	8.8	7.3
Muzzle Ring, diameter		11.9	11.5	11.	9.2	9.	7.8	6.5	5.3
From the Second Reinforce to the Trunnions		4.	4.	1.2	1.	0.5	0.6	0.4	0.4
Trunnions, diameter		6.4	5.8	5.2	4.6	4.2	3.6	2.9	2.3
Ogees, each, diameter		1.7	1.7	1.7	1.4	1.4	1.3	1.2	1.1
Total length of ye Cascable		12.	12.	12.	11.	11.	10.	9.	7.5
Diameter of ye first Fillett		18.	17.	16.	15.	15.	13.6	13.	12.
Diameter of ye Second Do.		10.	9.	8.	7.	6.5	5.5	5.	4.

RAI, Adye (1766), pp. 12-14.

Appendix J. Dimensions of Brass Field Pieces (1766)

Nature of the Gun [Pounder]		24	12	6	3
Total length of the Gun	Ft.	5.5	5.0	4.5	3.5
First Reinforce	Inches				
Length		19.5	18.	15.6	
Greatest Diameter		11.6	9.6	8.7	
Least Diameter		11.	8.7	8.6	
Second Reinforce					
Length		13.	12.	10.9	
Greatest Diameter		10.3	7.6	7.3	
Least Diameter		9.6	7.	5.8	
Chase					
Greatest Diameter		9.	6.4	5.	
Least Diameter		7.7	5.	4.	
Base Ring					
Breadth		1.	0.9	0.9	
Diameter		12.2	10.2	9.4	
Ogee, next to it		1.3	1.	1.	
Vent Field, length		4.	3.5	3.	
Chase Girdle, length		3.5	3.3	3.	
From the Chase Girdle to the Muzzle Astragal		9.	9.	8.8	
Diametear at ye Muzzle Swelling		12.3	9.7	7.8	
---- at ye Muzzle Ring		10.3	7.6	7.3	
From the Chase to ye Trunnions		1.3	6.	1.	
Diameter of the Trunnions		4.7	3.4	3.	
Length of ye Cascable		7.5	7.	6.	
To ye first Fillett		6.	5.5	5.	
To the Second Do.		6.4	5.4	5.	
Diameter of the Button		3.7	2.9	2.9	

N.B. These Guns have no other Mouldings besides ye Base Ring & Ogee next to it. The Ogees have no fillets except that at the Muzzle which has two fillets like all other Guns & the Reinforce is join'd by a little Cavity. There is a small Ring cast under the Neck of the Cascable to fix the Elevating Screw, which is used with light Field Pieces, instead of Coins or Wedges.

Source: RAI, Adye (1766), op. cit., pp. 18-19.

Appendix K. Dimensions of Iron Ship & Garrison Guns of Different Calibres (1766).

Nature of the Gun	Pdrs.	32	24	18	12	9	6	3	1 1/2
Total Length	Feet	9.5	9.5	9.	9.	8.5	6.5	4.5	3.
First Reinforce	Inches								
Length		32.	31.2	29.	29.	28.	21.	14.5	10.
Greatest Diameter		20.	19.1	17.8	16.1	15.2	15.2	13.7	10.6
Least Diameter		18.8	17.8	16.8	15.2	14.2	14.2	12.7	9.8
Second Reinforce									
Length		22.8	22.	21.	19.7	18.7	15.	10.	6.7
Greatest Diameter		18.	16.9	16.1	14.3	13.5	13.5	11.9	9.4
Least Diameter		17.2	16.3	14.4	13.6	12.7	12.7	11.3	9.
Chase									
Greatest Diameter		16.2	15.4	14.6	12.	11.9	11.	10.5	8.3
Least Diameter		13.8	12.7	11.7	9.8	9.6	9.3	8.4	6.8
Base Ring									
Breadth		2.1	1.9	1.9	1.6	1.6	1.6	1.4	1.8
Diameter		21.8	20.8	19.4	17.9	16.8	15.3	11.5	6.4
Vent Field, length		4.9	4.4	4.	3.6	3.6	3.	2.1	1.2
---- Astragal, diameter		1.5	1.4	1.3	1.3	1.2	1.2	0.8	0.5
First Reinforce Ring									
Breadth		1.2	1.2	1.1	1.1	1.	1.	0.8	0.5
Diameter		19.5	18.4	17.3	15.7	14.6	13.2	10.2	5.6
Second Reinforce Ring									
Breadth		1.2	1.2	1.1	1.1	1.	1.	0.8	0.8
Diameater		17.7	16.9	15.8	13.8	13.2	12.8	9.2	4.9
Chase Girdle, length		5.1	4.2	4.	4.	4.	3.9	2.1	0
---- Astragal, breadth		1.5	1.4	1.3	1.2	1.1	1.	0.9	0
From ye Muzzle to the Muzzle Astragal		17.	16.	15.5	14.	14.	13.2	7.5	5.6
Muzzle Astragal, breadth		1.6	1.6	1.4	1.4	1.3	1.2	1.	0
Swelling of the Muzzle, diameter		17.7	16.6	15.5	13.8	13.	13.	11.3	9.
Muzzle Ring, diameter		13.8	12.7	11.7	9.8	9.6	8.4	6.8	3.4
From the Second Reinforce to the Trunnions		1.5	2.	0.9	1.	0.5	0.5	0.5	1.8
Trunnions, diameter		6.1	5.5	5.	4.6	4.2	3.5	2.7	1.6
Ogees, each diameter		2.1	2.1	2.1	2.	2.	1.2	1.2	1.0
Total length of Cascable		12.	12.	11.	10.	9.	8.	6.5	5.
Diameter of ye First Fillett		18.	17.	16.	14.	14.	12.	11.	9.
Diameter of the Second Do.		10.	9.	7.5	7.	5.5	5.	4.5	3.5

RAI, Adye (1766), pp. 15-17.

Appendix L. Table of the Length Weight Calibre and Principal Dimensions of the Brass Ordnance of each Nature according to the present Establishment in Great Britain 1778.

Nature	Heavy					Comn. Medium				Genl. Desaguliers			
Pounders	42	24	12	6	3	24	12	6	3	12	6	3	1
Weight [Cwt.]	61/0/0	53/2/0	31/2/0	19/1/14	11/2/0		21/3/0	12/1/17	6/0/0	23	12 1/4	5 3/4	
Length in Feet	9.5	9.5	9	8	7	8.5	6.5	7	3.5	7.5	7	6	5
Diameters													
On the Base Ring	21.75	19.5	15.75	13.46		18.6	14.916	11.5	9.583	15.1	11.45	9.0	6.75
Before the Base Ring		18.02	14.1			17.5	13.85			13.0	9.9	7.8	
On the first Reinforce Ring		17.52	13.7			16.65	13.5			12.87	9.85	7.6	
Behind the first Reinforce Ring	19.0	17.0	13.5	11.025		16.45	13.166	9.508	7.833	12.5	9.6	7.3	5.25
Before the first Reinforce Ring	18.166	16.25	12.666	10.508		15.7	12.5	9.5	7.75	12.3	9.5	7.2	5.25
On the second Reinforce Ring		15.87	12.55			15.2	12.25			12.0	9.2	7.15	
Behind the second Reinforce Ring	17.5	16.5	12.333	10.75		15.0	12.0	9.0	7.333	11.8	9.1	6.85	4.916
Before the second Reinforce Ring	16.5	14.508	11.508	9.333		14.2	11.416	8.833	7.25	11.35	8.85	6.75	4.916
At the Muzzle Astragal	13.916	12.0	9.666	8.093		11.11	9.508	6.333	5.166	8.7	6.5	5.0	3.416
At the swell of the Muzzle	17.166	15.5	12.666	10.416			12.0	8.833	7.0	11.75	8.8	6.95	3.666
Thickness of Metal													
Before the Base Ring						5.84				4.19	3.12	2.445	
At the Muzzle Astragal	3.443	3.085	2.518	2.221		2.14	2.439	1.336	1.128	2.04	1.42		0.698
At the Charging Cylinder above the calibre													

Nature	Light						
Pounders	24	12	6		3		
Weight [Cwt.]				5/1/0	2/3/4	1/2/18	1/3/14
Length in Feet	5.5	5	5	4 1/2	3 1/2	3	3
Diameters							
On the Base Ring	14.25	11.225	9.7	9.666	7.333	6.75	7.166
Before the Base Ring	13.5	10.65	8.7				
On the first Reinforce Ring			8.25				
Behind the first Reinforce Ring	12.85	10.05	8.05	8.0	6.508	5.75	6.083
Before the first Reinforce Ring	12.15	9.5	7.75	7.75	6.25	5.5	5.916
On the second Reinforce Ring			7.75				
Behind the second Reinforce Ring	11.65	9.1	7.467	7.333	6.166	5.25	5.33
Before the second Reinforce Ring	11.0	8.5	7.1	7.0	5.75	5.0	5.083
At the Muzzle Astragal	9.9	7.75	5.95	5.916	5.0	4.291	4.5
At the swell of the Muzzle		9.7	7.35	7.333	6.508	5.333	5.508
Thickness of Metal							
Before the Base Ring	3.84	3.015	5.04				
At the Muzzle Astragal	2.04	1.56	1.145	1.128	1.045	0.69	0.79
At the Charging Cylinder above the calibre							

Adapted from RAI, Walton, "Gunnery Tables 1780-1792...," unpaginated.

Appendix M. Dimensions of the External parts and Calibre of Iron Guns of each Nature and Length in Inches and Decimals. November 1780

Natures	42	32	24		18	12			9			6			4		3
Length in Feet	9.5	9.5	9.5	9	9	9	8.5	7.5	8.5	7.5	7	9	8	6	6	5.5	4.5
Diameters [inches]																	
On the Base Ring	22.8	21.8	21.	20.75	19.4	18.03	18.	17.18	17.	17.	17.	15.88	15.8	15.5	13.6	13.6	11.6
Before the Base Ring	21.	19.96	19.1	19.1	17.67	16.16	16.2	16.1	15.16	15.3	15.4	14.3	14.0	13.85	12.1	12.05	10.55
On the first Reinforce Ring	20.47	19.4	18.47	18.5	17.17	15.7	15.65	15.95	14.7	14.76	14.84	13.55	13.5	13.52	11.75	11.84	10.2
Behind the first Reinforce Ring	20.1	18.9	17.97	18.05	16.7	15.2	15.17	15.43	11.2	14.36	14.2	12.97	13.0	13.02	11.3	11.34	9.8
Before the first Reinforce Ring	19.3	17.95	17.05	17.24	15.76	14.33	14.32	14.6	13.34	13.42	13.4	12.2	12.75	12.18	10.57	10.57	9.3
On the Second Reinforce Ring	18.75	17.66	16.82	16.9	15.57	14.15	14.1	14.6	13.15	13.25	13.22	12.0	12.05	12.05	10.52	10.57	9.15
Behind the Second Reinforce Ring	18.47	17.16	16.32	16.45	15.07	13.65	13.6	14.1	12.63	12.75	12.8	12.52	11.55	11.55	10.25	10.07	8.75
Before the Second Reinforce Ring	17.6	16.22	15.35	15.5	14.15	12.75	12.75	13.3	11.76	11.86	11.7	10.7	10.7	10.67	9.3	9.3	8.25
At the Muzzle Astragal	15.25	14.15	13.08	13.3	12.73	10.9	11.0	11.12	10.16	10.15	10.5	9.2	9.2	9.35	8.18	8.18	7.15
At the swell of the Muzzle	18.63	17.16	16.82	16.85	15.5	14.05	13.9	13.8	13.15	13.25	13.3	11.87	12.05	11.95	10.4	10.52	9.05
Thickness of Metal																	
Before the Base Ring	6.98	6.77	6.63	6.63	6.19	5.76	5.78	5.73	5.47	5.54	5.59	5.32	5.27	5.09	4.44	4.42	3.82
At the Muzzle Astragal	4.11	3.86	3.62	3.73	3.42	3.13	3.18	3.14	2.97	2.97	3.14	2.77	2.77	2.84	2.48	2.48	2.12
At Charging Cylinder above ye Calibre		.35	.8	.8	.9	1.13	1.15	1.10	1.26	1.33	1.38	1.66	1.61	1.43	1.23	1.21	0.91
Distance																	
From behind the Base Rg to ye hinder part of the Trunnion	45.35	45.65	45.95	43.37	43.64	43.97	41.4	36.3	41.61	36.51	33.9	44.45	41.1	29.01	29.24	26.66	20.63
From Do. to the First Reinforce	32.5	32.5	32.5	30.8	30.8	30.8	29.14	25.7	29.14	25.7	24.0	30.8	27.4	20.56	20.56	18.8	15.4
From Do. to the Second Reinforce	25.1	26.15	26.73	24.97	25.5	26.7	24.5	21.07	24.93	21.5	19.8	27.18	23.76	16.9	17.35	15.63	12.5
Diameter of the Calibre	7.03	6.42	5.83		5.29	4.63			4.21			3.66			3.21		2.91

Adapted from RAI, Walton, op. cit., unpaginated. It is very difficult to interpret the "Distance" which is said to be from behind the base ring to the second reinforce; if it means to the end of the reinforce this creates a rather long second reinforce and a consequently short chase.

APPENDIX N
Armstrong's, Blomefield's, and Desaguliers' Construction of Guns*

General Armstrong's construction of heavy iron guns

A scale is formed of the diameter of the bore or calibre divided into 32 equal parts, from whence the several dimensions of metal in guns of different natures is given in the following table.

Nature of Guns	Diameter of the Calibre	Thickness of metal at the breech, or begining of the 1st reinforce	Thickness of metal at the end of the 2d reinforce	Thickness of metal at the muzzle astragal
	Inches	Parts of the calibre	Parts of the calibre	Parts of the calibre
42	7.018	32	27	18
32	6.410	34	28	19
24	5.823	36	29	20
18	5.292	38	30	21
12	4.623	40	31	22
9	4.200	42	32	23
6	3.668	44	33	24
4	3.204	44	33	24
3	2.913	44	33	24
1	2.019	44	33	24

*The various plates and draughts referred to in the text were not found with the Ms.

Construction of a 24 Pr. iron gun

On a given line AB representing the axis of the piece, set off in feet and inches the given length of the piece, and draw lines CD, EF each distant from it the semi-diameter of the calibre, which will represent the bore.

The length of the piece is divided into seven equal parts. From the two sevenths G a line GH is draw perpendicular to the axis AB, for the length of the first reinforce; the length GI of the second reinforce is equal to one seventh plus one diameter of the calibre terminated by a line IK perpendicular to the axis, and the remainder IL will be for the chace.

The breech AM is equal to the greatest thickness of metal NO equal to 36 parts, or one diameter and four parts.

The thickness of metal PK, at the extremity of the second reinforce, is equal to 29 parts, to which 2 parts KR are added, then in the direction O and R a line QH is drawn, representing the exterior surface of the first reinforce. The second reinforce is determined by a line KS drawn through K, parallel to the exterior surface of the first reinforce.

The breadth of the base-ring and mouldings Aa is equal to 1/32 part of the length of the piece AB.

The first and second reinforce rings and their moulding bc, de are each equal to 3/4 the base ring and mouldings Aa. The ogees are equal to their respective rings. The astragals and fillets f are 1/3 the base ring and ogee, and all the fillets are half the astragals.

The projection of the mouldings are half the fillets excepting those of the muzzle which are the whole breadth of the fillets.

The length FU of the muzzle is equal to the diameter of the second reinforce ring.

The thickness of metal PT at the beginning of the chace is also diminished by 2 parts, and its outline TV is drawn to the muzzle astragal, where the thickness of metal UV is equal to 20 parts.

The axis XY of the trunnions is perpendicular to the axis of the piece, placed at the 3/7 of the length of the piece from the extremity of the breech. The centre Z of the trunnions is placed half a calibre below the axis of the piece; their diameters are one calibre, and their lengths the same, allowing for the projection of the second reinforce ring; their faces hi are parallel to the axis of the piece.

The vent field ag, is determined by placing the vent astragal f, 1/4 of the calibre before the bottom of the bore M.

The breadth ek of the chace girdle is equal to the breadth ag of the vent field.

The diameter lm of the base ring is determined by lines produced touching the extremities of the first and second reinforce rings.

The pan M, extends from the base ring to the centre of the vent astragal; its breadth is 2 1/2 inches, and its sides are made parallel to the axis of the piece; its projection is determined by a line lo drawn through l the extremity of the diameter of the base ring parallel to the exterior surface of the vent field.

The vent no, is 2/10 of an inch in diameter; it is situated at the bottom of the bore in n, and its direction is such, as that when produced it may meet the lower surface of the bore at 4 parts of the calibre from its extremity N.

The bottom Nn of the bore is a plane surface, meeting the sides in a small arc, described with a radius of 1/24 part of the calibre.

Muzzle Pl: [Plate]

The length DE of the muzzle is equal to the diameter of the second reinforce ring. The length DN of the neck is equal to 1/5 DE the length of the muzzle, and through N a line NE is drawn parallel to the axis of the piece, which will determine the thickness of metal at the face.

Take BA equal to the breadth of one of the reinforce rings and ogees, for the centre of the swell, and its diameter HK is made equal to that of the second reinforce ring.

Take KI equal to 1/4 AB, from I as a centre and with IK as a radius describe the arc RKS, draw IR parallel to the axis of the piece, which will determine the diameter of the fillet RP. Take KS equal to 1/3 KR; and from N and S as centres and with 5 diameters of the bore FG as a radius describe two arcs cutting each other in O; from O as centre and with the same radius NO describe the hollow or cavetto, NS.

After having drawn the two fillets R, E the ogee ab is described by equilateral triangles.

Cascable Pl: [Plate]

The length AB of the cascable is equal to 2 diameters and 9 parts of the calibre.

The distance Bh from the extremity B of the breech to the last fillet EF is equal to 24 parts.

The diameter EF of the last fillet is 1 diameter and 16 parts.

The breadths Bc, gf of the ovolos are each equal to 4 parts.

The ogee CK is described by isosceles triangles.

The diameter of the button mn, is 1 calibre 8 parts; the diameter kl of the neck, is equal to that of the bore; from G as centre and with 34 parts as a radius describe an arc in M, and from E with a radius of 14 parts cut the former arc; from their intersection as centre and with ME as a radius describe the arc EkN.

General construction for brass guns, upon the late General Armstrong's principle

The general dimensions of heavy, medium and light brass guns are as follows expressed in 1/32 parts of their respective calibres.

		Heavy	**Medium**	**Light**
		Parts	**Parts**	**Parts**
Thickness of metal	at the breech and commencement of the first re-inforce	33	32	22
	at the end of the second re-inforce	26	25	16
	at the muzzle astragal	17	16	10
Trunnions	Diameter	32	30	20
	Length	32	30	24
Cascable	From the extremity of the base-ring to that of the breech mouldings	12	10	9
	From the end of the breech mouldings to the centre of the button	30	24	24
	Breadth of the ovolo, or 1/4 round	4	3	3
	Diameter (of the button	32	26	26
	(of the neck	26	22	20
	(of the last fillet	48	44	36

The lengths and constructions, of the reinforces of heavy and medium brass guns, are subject to the same rules as those in iron guns. In light brass guns, the length of the piece must be divided into 18 equal parts of which

5 parts are taken for the breech and 1st reinforce
4 parts for the 2d reinforce
9 parts for the chace
2 1/2 parts for the length of the muzzle
1/2 part for the length of the neck of the muzzle.

The axis of the trunnions are placed 8 parts from the breech, and half a calibre below the axis of the piece.

The position of the trunnions of heavy and medium brass guns, are the same as those of iron.

The trunnions of medium and light guns have shoulders, which are 1/10 of the diameter of the trunnion in breadth, and of sufficient depth to clear the projection of the second reinforce-ring.

Their faces are parallel to the axis of the piece; in heavy guns, which have no shoulders to their trunnions an allowance must be made for the projection of the reinforce-rings.

The vent fields are one seventh of the breech and first reinforce.

The chace girdles are 1/14 part of the chace.

The lengths of the muzzles are equal to the diameters of the second reinforce-rings, in heavy guns, and in medium guns 1/7 part of the lengths of the piece.

The diameters of the swells of the muzzles are equal to the diameters of the second reinforce-rings.

The bottoms of the bores of heavy brass guns are constructed as in iron guns, in medium and light guns, they are hemispherical, and their vents form an angle of 75 degrees with the axis of the piece, meeting it in light guns 1/3 of a calibre and in medium 1/4 of a calibre, from the extremity of the bore.

The vents in heavy brass guns are the same as in iron.

The mouldings of the piece differ in some measure from those of iron guns; but their general proportions are the same, excepting those of the breech and cascable, the construction of which is explained in the draught.

In medium and light guns, there is a projection of metal beneath the neck of the cascable, for receiving the loop of the elevating screw, the lower part of it is the arc of a circle described with a radius equal to the semi-diameter of the neck. The position of its centre is 1/4 part of the distance from the extremity of the breech mouldings to that of the button, and is 1/14 of the diameter of the neck below it.

Medium and heavy guns are cast with dolphins, by which they are occasionally suspended and consequently ought to be placed over the centre of gravity of the piece, or rather so as that the breech may preponderate in a very small degree. In pieces of the above construction, the points of suspension are 3/4 of a calibre; in heavy and in medium guns 1/2 a calibre behind the axis of the trunnions.

The interior height of the dolphins of heavy guns is 14/32 of the calibre, and in medium guns 12/32 their form is nearly semi-circular.

The greatest diameter of the dolphins is 1/2 a calibre, and the least thickness 1/3 nearly; their directions lie parallel to the outline of the second reinforce, and their fore parts are distant from each other one calibre.

The ornaments of the piece are a shell at the vent, the arms of His Majesty, upon the first reinforce, and those of the Master General upon the chace of heavy and medium guns; but their cypher only are engraved on light guns.

On the base-ring is engraved the name of the Founder, and the date when the piece was cast.

Table of the length, weight, calibres and diameters of shot of iron guns, of each nature, according to the present establishment in great Britain 1764, with the weight of powder for proof and service

Iron Guns	Weight of powder for proof		Length of each gun		Weight of Metal			Calibre of each nature of guns	Diameter of the shot	Weight of powder for service	
Pounders	Lb	oz	Feet	In	Cwt	Q	lb	Inches	Inches	Lb	oz
42	25	0	9	6	65	0	0	7.018	6.684	14	0
32	21	8	9	6	55	0	0	6.410	6.105	10	10
24	18	0	9	6	49	0	0	5.823	5.547	8	0
	15	0	9	0	47	2	0				
18	15	0	9	0	40	0	0	5.292	5.040	6	0
12	12	0	9	0	32	2	0	4.623	4.400	4	0
			8	6	31	2	0				
			7	6	29	1	0				
9	9	0	9	0	29	0	0	4.200	4.000	3	0
			8	6	27	2	0				
			8	0	26	2	0				
			7	6	24	2	0				
			7	0	23	0	0				
6	6	0	9	0	24	0	0	3.668	3.498	2	0
			8	6	23	0	0				
			8	0	22	0	0				
			7	6	20	2	0				
			7	0	19	0	0				
			6	6	18	0	0				
			6	0	16	2	0				
4	4	0	6	0	12	1	0	3.204	3.053	1	5
			5	6	11	1	0				
3	3	0	4	6	7	1	0	2.913	2.775	1	0
1/2	0	8	3	0	1	1	25	1.580	1.505	0	3

Table of the length, weight, calibres and diameters of shot, of brass guns of each nature, according to the present establishment in great Britain 1764 with the weight of powder for proof and service

Brass Guns	Pdr	Weight of powder for proof		Length		Weight of metal			Calibre of each nature of guns	Diameter of the shot	Weight of powder for service	
		Lb	oz	Ft	In	C^{wt}	Q	lb	Inches	Inches	Lb	oz
Heavy	42	31	8	9	6	61	0	0	7.018	6.684	14	0
	24	21	0*	9	6	53	0	9	5.823	5.547	8	0
	12	12	0	9	0	29	0	0	4.623	4.403	4	0
	9	9	0	9	0	26	0	0	4.200	4.000	3	0
	6	6	0	8	0	19	0	0	3.668	3.498	2	0
	3	3	0	7	0	11	2	0	2.913	2.775	1	0
	1 1/2	1	8	6	0	5	2	0	2.310	2.201	0	8
Medium	24	18	0	8	0	40	1	21	5.823	5.547	8	0
	12	9	0	6	6	21	0	14	4.623	4.403	4	0
	6	6	0	5	0	10	1	12	3.668	3.498	2	0
Light	24	10	0	5	6	16	1	12	5.823	5.547	8	0
	12	6	0	5	0	8	3	18	4.623	4.403	4	0
	6	3	0	4	6	4	3	14	3.668	3.498	2	0
	3	1	8	3	6	2	3	4	2.913	2.775	1	0

* (corrected in MS from 12)

Colonel Blomefield's general construction for Brass guns

A scale must be formed of the calibre or diameter of the bore, divided into sixteen equal parts, from whence the thickness of metal in guns of different natures is given in the following table

Brass Guns	Length	Length		Weight of metal			Thickness of metal GI or AY at the breech	Thickness of metal KL at the muzzle
Pounders	Calibres	Feet	In	Cwt	Q	lb	Equal parts	Equal parts
12	17	6	6.660	18	0	0	14	6
9	17	5	11.400	13	2	0	14	6
6	17	5	2.356	9	0	0	14	6
3	17	4	1.521	4	2	0	14	6
24	13	6	3.669	24	0	0	12	6
18	13	5	8.796	18	0	0	12	6
12	13	5	0.099	12	0	0	12	6
6		5	0.000	6	0	0	11	4
3		6	0.	6	0	0	14	6
1		5	0.	2	2	0	14	6

Guns	Diameter mn		Neck op		Radius An or AB		Radius BC	
	Cal	Part	Cal	Part	Cal	Part	Cal	Part
17 Calibres	1	0	0	9	0	4 1/2	0	6
13 Calibres	1	0	0	9	0	4 1/2	0	6
Pummel 6 poundr 5 feet and 6 Cwt	1	2	0	10	0	5	0	6 1/2
3 por of 6 feet	1	0	0	12	0	8	0	8
1 por of 5 feet	1	0	0	12	0	8	0	8

In the above guns, the diameter of the swell of the muzzle, is so proportioned, to that of the base ring, as to give a dispart of one degree.

Construction of Colonel Blomefield's light 24 pounder brass gun, length 13 calibres weight 24 Cwt.

The diameter of the calibre or bore of a 24 pounder is equal to 5.823 inches, and is divided into 16 equal parts, by which scale the several dimensions of the gun are determined.

On a given line AB representing the axis of the piece 13 calibres are set off, for the length of the gun and on each side of it parallels are drawn at the distance of half a calibre, or 8 parts, which will represent the bore.

The length of the piece is divided into 18 equal parts, (which parts are marked on a line drawn parallel to the axis AB and at any distance from it). From the 5th division, on indefinite line 5C is drawn perpendicular to the axis AB, for the length of the first reinforce

AC; the length CD of the second reinforce, is equal to 4/18 determined in a like manner by a line 9D perpendicular to the axis AB, and the remaining 9/18 will be for the chace DB.

The thickness of metal FG at the breech is equal to 12 parts, and that HI at the face is equal to 6 parts of the calibre, and the lines GI, KL being drawn will determine the exterior surface of the chace.

Through G draw GN parallel to the axis AB, bisect NO in c and join GC, which will be the exterior surface of the first reinforce. Through O draw OP parallel to the axis AB, bisect PQ in e and join ce, which will be the exterior surface of the second reinforce.

The axis RS of the trunnions is perpendicular to that of the piece placed at the distance of 8/18 of the length of the gun, from the extremity of the breech: their centre T is half a calibre below the axis of the piece.

The diameter of the trunnions is equal to 1/3 GK the diameter of the breech, and their length, RS the same.

The breadth of the shoulders is equal to 1/10 the diameter of the trunnions, and their projection is equal to that of the second reinforce-ring, made parallel to the axis of the piece.

The thickness of metal Af is equal to FG equal to 12 parts, and the bottom of the bore is semi-elliptical described from the several centres, a,b,c; the first a is at the distance of one calibre from f, and those b and c, are each at the distance of 3 parts from h and i taken on the line hi passing through g of 1/4 of the calibre from f the bottom of the bore and perpendicular to the axis of the piece.

The breadth Am of the base-ring is equal to 4 parts, and is [its] ogee mn is to 3 parts of the calibre.

The vent field no is equal to 13 parts.

The astragal and fillets are equal to 3/4 the base-ring, and the fillets half the astragals.

The breadth of the first and second reinforce-ring are each equal to 3/4 the base-ring, and the second reinforce-ogee is equal to 3/4 of its respective ring.

The projection of the mouldings are half the fillets; excepting those at the muzzle, which are the whole breadth of the fillets.

The pan extends from the base-ring to the fillet of the vent field astragal, and its breadth is 2 inches. Its projection is determined by drawing a line tangent to the swell of the ogee, parallel to the surface of the vent field, meeting the fillet of the vent field astragal.

The vent tv is 2/10 of an inch in diameter, and takes its direction tv in a line with g of 1/4 of the diameter of the calibre from f the bottom of the bore, meeting the intersection t formed by the surface of the pan and the line ft drawn from the bottom of the bore, perpendicular to the axis of the piece.

The projection of the diameter of the base ring is 2 parts, and its surface is determined by a line produced touching the extremities of the first and second reinforce ring.

Muzzle

The length BE of the muzzle is equal to 1/5 BD the length of the chace. The centre a, or e of the swell from the face B is equal to 1/6 BE, and ac is equal to 1/3 aB. The diameter of the swell of the muzzle is equal to 2 diameters and 5 parts, and is described from e as a centre and with a radius equal to ac; through e draw el parallel to the axis, which will determine the diameter of the fillet, make ik equal to 1/3 kl; from d and i as centres, and with the diameter of the swell as a radius describe two arcs intersecting each other in m, and with the same radius, from m as a centre describe the cavetto or hollow di.

Cascable

The outline of the breech GUK, is concentric with the arc kl the bottom of the bore, described with the radius aG.

The length AB of the cascable is equal to 1 calibre 5 parts, the diameter of the last fillet is equal to the diameter of the bore, the diameter of the button is equal to 12 parts; from C as a centre and with a radius of 10 1/2 parts describe an arc in r, and from q with a radius of 4 1/2 parts cut the former arc; from their intersection r as a centre and with the same radius of 4 1/2 parts describe the neck, the ogee ih is described by iscoceles triangles, and compleated according to the dimensions given in the draught.

Construction of a brass 12 pounder; its length being 17 calibres, and its weight 18 Cwt. according to Colonel Blomefield's principle

The diameter of the calibre of a 12 pounder is 4.623 inches, divided into 16 equal parts, by means of a diagonal scale.

On a line given AB representing the axis of the piece 17 calibres are set off for the length of the gun; and on each side of it, parallel lines are drawn at the distance of half a calibre, which will represent the bore.

The length of the piece is divided into 18 equal parts, 5 of which are for the length of the first reinforce AC, expressed by the perpendicular 5C. 4 are given to the second reinforce CD, and the remaining 9/18 are for the chace.

The length BE of the muzzle is equal to 1/5 DB the length of the chace.

The thickness of metal FG at the breech is equal to 14 parts, and that HI at the neck of the muzzle is equal to 7 parts of the calibre, and the lines GK, LM being drawn will determine the exterior surface of the chace.

Through G, draw GN parallel to the axis; bisect NO and join cG which will be the exterior surface of the first reinforce; through O draw OP, parallel to the axis; bisect PQ and join ce, which will be the exterior surface of the second reinforce.

The axis RS of the trunnions is perpendicular to that of the piece, placed at the distance of 8/18 of the length of the gun, from the extremity of the breech. Their centre T, is placed half a calibre below the axis of the piece. The diameter mn of the trunnions is equal to 1/3 GL the diameter of the breech, and their length Rq the same, allowing for the projection of the second reinforce-ring, and their faces are parallel to the axis of the piece. The breadth of the shoulders of the trunnions, is equal to 1/10 of their diameter, and the projection equal to that of the second reinforce ring, made parallel to the axis of the piece.

The thickness of metal Af is equal to the greatest thickness of metal FG, equal to 14 parts. The bottom of the bore is semi-elliptical, described from the several centres a,b,c; the first a is taken in the axis of the piece of 1 calibre from f the bottom of the bore, and those b and c are each distant of 3 parts, from h and from i, taken in the line hi passing through g, of 1/4 of the calibre from f the bottom of the bore, and perpendicular to the axis of the piece.

The outline GKL of the breech, is concentric with the arc of the bottom of the bore, described with the radius aG.

The breadth Al, of the base-ring is equal to 1/18 AC the length of the first reinforce, equal to 4 parts of the calibre, and the ogee is equal to 3/4 the base-ring, or 3 parts of the calibre.

The breadth of the first and second reinforce rings are each equal to 3/4 the base-ring; and the second reinforce ogee is equal to 3/4 its respective ring.

The astragal and fillets are 3/4 of the base-ring, and the fillets are half the astragals.

The projection of the mouldings are half the breadth of the fillets, excepting those at the muzzle, which are equal to the whole breadth of the fillets.

The projection of the base ring is 2 parts, and its surface is determined by lines produced touching the extremities of the first and second reinforce ring.

The vent field mn is determined by placing the centre of the the vent astragal n one calibre from the ogee m.

The pan f extends from the base ring l, to the fillet of the vent astragal, and its breadth is 2 inches.

The vent is 2/10 of an inch in diameter, and takes its direction ek in a line with g of 1/4 of the diameter of the calibre, from the bottom of the bore, meeting the intersection k made by the surface of the pan, and the line fk drawn from the bottom of the bore perpendicular to the axis of the piece.

Muzzle

The length BE of the muzzle is 1/5 BD the length of the chace; the neck EL, is 1/3 EB the length of the muzzle. The centre d or e of the swell is distant from the face B, 1/6 the length of the muzzle, and the breadth aB of the muzzle-mouldings equal to 2/3 Bd. The diameter FN of the swell is so proportioned to that of the base ring as to give a dispart of one degree; and is described with a radius eN, equal to 1/3 Bd. The cavetto or hollow cg, is described with a radius cf equal to four times the thickness of metal ig of the neck; the diameter of the fillet mn, is determined by a line en drawn through the centre e of the swell parallel to the axis of the piece.

Cascable

The length AM of the cascable, is 1 calibre 6 1/2 parts. The diameter UV, of the last fillet, is 1 calibre. The distance KN from the last fillet to the centre of the button is 10 parts, and the button is described with a radius of 6 parts. From N as a centre and with a radius of 10 1/2 parts describe an arc in x and from V with a radius of 4 1/2 parts cut the former arc, from their intersection x as centre and with xV as a radius describe the arc VRy, which will be the neck; the ogee Vsr is described by iscoceles triangles, and is compleated as may be obtained from its dimensions given in the draught.

Construction of a light 6 pounder, brass gun its length being 5 feet and weight 6 Cwt. according to Colonel Blomefield's principle (Fig. 1)

On a given line AB, representing the axis of the piece, five feet are set off which will be the length of the gun.

The diameter of its calibre is 3.668 inches, divided into 16 equal parts.

Lines are drawn parallel to the axis AB, each distant from it the semi-diameter of the calibre, which will represent the bore.

The length of the gun is divided into 18 equal parts (these parts are marked on a line drawn parallel to the axis AB and at any distance from it). From the 5th division a line 5C is drawn perpendicular to the axis AB, which will be the length of the first reinforce AC. The length of the second reinforce CD is made equal to 3/18 plus 1 diameter of the calibre, and determined in a like manner by a line drawn perpendicular to the axis of the piece; the remaining 9/18 are for the chace.

The length of the muzzle Bf is equal to 1/5 DB, the length of the chace.

The thickness of metal EF at the breech is equal to 11 parts, and that at the face GH is 4 parts of the calibre, and the lines FH, PS being drawn will determine the exterior surface of the chace. Through F draw FI, parallel to the axis; bisect IK and join Fe, which will be the exterior surface of the first reinforce; through K draw KL parallel to the axis; bisect LM, and join en, which will be the exterior surface of the second reinforce.

The axis NO of the trunnions is perpendicular to that of the piece, and placed 8/18 of the length of the gun, from the extremity of the breech; their centre d is placed 1/18 of the diameter of the trunnion above the lower surface of the bore. The diameter of the trunnions is 1/3 the diameter FP of the breech, and their length the same, allowing for the projection of the second reinforce ring. The breadth of the shoulders be, is equal to 1/10 ab the diameter of the trunnion, and their projection is equal to that of the second reinforce ring, made parallel to the axis of the piece.

The thickness of metal As, is equal to that EF equal to 11 parts. The bottom of the bore is semi elliptical described from the several centres g, h, i; the first g is distant 1 calibre from the bottom of the bore, and those i and h are distant 3 parts from k and from m, taken in the line km, distant 1/4 of the calibre from s the bottom of the bore, and perpendicular to the axis of the piece.

The outline FQP of the breech is concentric with the arc op of the bottom of the bore, described with the radius gF.

The breadth Al of the base ring is equal to 1/18 AC, the length of the first reinforce, and the ogee 3/4 of the base ring.

The breadth of the first and second reinforce rings, are 3/4 the base ring Al, and the breadth of the second reinforce ogee, is equal to 3/4 its respective ring.

The astragals and fillets, are 3/4 the base ring, and all the fillets are 1/2 the astragals.

The projections of the mouldings are half the fillets, excepting those at the muzzle, which are equal to the whole breadth of the fillets.

The projection of the base ring is 2 parts, and its surface is determined by lines produced touching the extremities of the first and second reinforce rings.

The vent field is determined by placing the centre of the vent astragal, one calibre from the ogee.

The pan extends from the base ring to the fillet of the vent astragal; its breadth is 2 inches, and its projection is equal to that of the swell of the ogee.

The vent is 2/10 of an inch in diameter and its direction rn is drawn from n 1/4 of the calibre from the bottom of the bore, to the intersection r formed by the surface of the pan and the line sr drawn perpendicular to the axis of the piece.

Muzzle

The neck ic is 1/3 Bf the length of the muzzle; the centre e of the swell is distant from the face B, 1/6 Bf, and the breadth Bn of the mouldings 2/3 Be: the diameter of the swell, is so proportioned to that of the base ring, as to give a dispart of one degree, and is described with radius ps equal to 1/3 Be; the cavetto or hollow dm is described with a radius om equal to 5 cd [?6cd] the thickness of metal at the neck; the diameter of the fillet is determined by a line drawn through r the centre of the swell, parallel to the axis of the piece.

Cascable fig: 2*

The length mk of the cascable is 1 calibre 6 parts; the diameter pq of the last fillet is 1 calibre 2 parts; the distance from the last fillet to the centre of the button is 10 parts, and the button is described with a radius of 6 1/2 parts; from l as a centre and with 11 1/2 parts describe an arc in o, and from p with a radius of 5 parts, cut the former arc, from their intersection o as a centre and with op as a radius describe the arc pbu, which will determine the neck, the ogee bci [?bei] is described by iscoceles sic triangles, of which the remainder of its construction is given in the draught, as also that of the loop for receiving the elevating screw.

*Figure 2 missing from Ms.

Table of the length, weight, calibres and diameters of shot of brass guns of each nature, with the weight of powder for proof, scaling and service, according to Colonel Blomefield's principle

Brass Guns	Pounders	Length		Weight of metal		Diameter of the calibre	Diameter of the shot	Windage	Thickness of metal			Weight of powder for						Nº of rounds for proof
									before the base ring	at the breech	at the muzzle ast.	Scaling		Proof		Service		
		Feet	In	C^wt^	Qrs	Inches	Inches	Inches	Inches	Inches	Inches	lb	oz	lb	oz	lb	oz	Number
17 Calibres	12	6	6.66	18	0	4.623	4.403	0.220	4.008	4.050	1.950	0	12	5	0	4	0	2
	9	5	11.40	13	2	4.200	4.000	0.200	3.650	3.670	1.800	0	10	3	8	3	0	2
	6	5	2.35	9	0	3.668	3.498	0.170	3.176	3.200	1.566	0	8	3	0	2	0	2
	3	4	1.52	4	2	2.913	2.775	0.138	2.533	2.548	1.238	0	4	1	8	1	0	2
13 Calibres	24	6	3.67	24	0	5.823	5.547	0.227	4.384	4.367	2.403	1	0	8	0	8	0	2
	18	5	8.78	18	0	5.292	5.040	0.252	3.945	3.950	2.194	0	12	6	0	6	0	2
	12	5	0.10	12	0	4.623	4.403	0.220	3.450	3.467	1.913	0	8	4	0	4	0	2
On the General Principle	6	5	0	6	0	3.668	3.498	0.170	2.496	2.521	1.086	0	4	2	0	2	0	3
	3	6	0	6	0	2.913	2.775	0.138	2.513	2.549	1.093	0	4	1	8	1	0	2
	3	4	0	3	0	2.913	2.775	0.138	1.978	2.002	0.863	0	2	1	0	1	0	3
	1	5	0	2	2	2.019	1.923	0.096	1.7005			0	1	0	8	0	6	2

Construction of Genl. Desagulier's [sic] brass 6 pounder, its length being 7 feet

A draught of Genl Desagulier's brass 6 pound^r natural size having been communicated to me by Col. Blomefield, without being informed of its construction I have, in order to ascertain it, made several scales of equal parts of the diameter of the calibre, amongst which I found the decimal division to answer best, according to this the following construction is described.

Construction

The diameter of the calibre being 3.668 inches, is divided into 100 equal parts by the means of a diagonal scale.

On a given line AB representing the axis of the piece, 7 feet are set off, for the length of the gun, and on each side of it parallel lines are drawn at the distance of half the calibre, which will be the bore.

The length of the gun is divided into 36 equal parts; 12 of them are for the length of the first reinforce AC, and 5 parts for the length CD of the second reinforce, and the remaining 19/36 are for the chace.

The length of the muzzle BE is equal to 4 parts.

The breech AF is equal to 1 calibre.

The greatest thickness of metal GH is equal to 85 parts of the calibre.

The thickness of metal IK at end of the first reinforce is equal to 80 parts of the calibre, and a line drawn HK will represent the exterior surface of the first reinforce.

The thickness of metal LM at the end of the 2d. reinforce, is equal to 74 parts, and a line KM drawn will represent its external surface.

The thickness of metal NO at the muzzle astragal, is equal to 37 parts of the calibre, and a line drawn MO will be for the exterior surface of the chace.

The axis XY of the trunnions is perpendicular to that AB of the piece, place at the 16/36 of the length of the gun, from the extremity of the breech. The centre of the trunnions is placed half a calibre below the axis of the piece.

The diameter of the trunnion is one calibre, and its length the same, allowing for the projection of its shoulder, which is 4 parts of the calibre, and its breadth 1/12 the diameter of the trunnions drawn parallel to the axis of the piece.

The breadth Aa of the base ring and ogee, is equal to 1/36 part the length of the gun, and the ogee is equal to the base ring.

The first and second reinforce rings and ogees, are each equal to 2/3 the base ring and ogee, divided into 9 equal parts, 4 of them are given to the rings and 5 to their respective ogees.

The astragals and fillets, are 1/3 the base ring and ogee and all the fillets are half the astragals.

The projections of the mouldings are half the fillets, excepting those at the muzzle and at the cascable which are the whole breadth of the fillets.

The breadth of the vent field is 1/36 part of the length of the gun, equal to the base ring and ogee.

The chace girdle is equal to the vent field.

The projection of the base ring is equal to 23 parts of the calibre, and the direction of its surface is in a line with that of the first reinforce ring.

The bottom of the bore is hemispherical, described with a radius equal to half the diameter of the calibre.

The vent is 2/10 of an inch in diameter and its direction, from the centre of the semicircle, forms an angle of 68 degrees with the axis of the piece.

Muzzle

The length OR of the neck of the muzzle is equal to 1/3 the length eB, and its external surface is determined by a line OR drawn parallel to the axis of the piece.

The diameter of the swell of the muzzle, is 2 calibres 42 parts, which admits a disport of 1 degree of elevation.

The thickness of metal PQ at the face is 41 parts.

The distance from the face B to the centre r or t of the swell is 1/7 the length eB of the muzzle, and is described with a radius of 1/3 Br, the breadth of the muzzle mouldings.

The diameter of the muzzle fillet is determined by a line drawn through the centre t of the swell, parallel to the axis of the piece, and its ogee is described by equilateral triangles.

Take ab equal to 1/3 ac, and from b, d as centres and with a radius equal to the length of the muzzle BE, describe the hollow or cavetto bd.

Cascable

The distance AS from the breech to the last fillet is 40 parts. The distance ST from the last fillet to the centre of the button is 77 parts. The diameter of the button is 85 parts.

The diameter gh of the last fillet is equal to 1 calibre 38 parts.

The diameter of the neck ef is equal to 66 parts taken on a line ef drawn parallel to gh at the distance of 34 parts; from f and g as centres and with 34 parts as a radius arcs are described intersecting each other in s; from s as centre and with sf as radius describe the arc gf; from f as a centre, with 60 parts as radius describe an arc in c; from T as centre with the semi diameter of the button and 60 parts as radius, cut the former arc, from their intersection c as centre and with cf as a radius describe the arc fi which will compleat the neck.

The breadth of the ovolo or quarter round is equal to 10 parts.

The ogee gl is described by iscoceles triangles whose equal sides are each equal to 3/4 gl.

The loop p is described with a radius of 32 parts and its centre o is placed 1/5 of ef below the neck.

The method of describing the dolphins and the shell of the vent, may be obtained from the draught.

Colonel Blomefield's general construction for garrison, land and sea service iron guns

A scale is formed of the diameter of the calibre or bore, divided into 16 equal parts, from whence the thickness of metal in guns of different natures is given in the following table.

Guns for Sea or Garrison Service

Nature Pounder	Length		Weight		Diameter of the		Windage	Thickness of metal at the		Diameter of the Base ring	Diameter of the swell of the muzzle
					Calibre	Shot		Breech	Neck		
	Feet	In	C^{wt}	Q	Inches	Inches	Inches	Parts of Cali	Parts of Cali	Inches	Inches
42	9	6	65	0	7.018	6.684	0.334	16	8	23.26	17.460
32	9	6	55	2	6.410	6.105	0.305	17	8 1/2	22.24	16.450
24	9	6	50	2	5.823	5.547	0.277	18	9	21.20	15.440
	9	0	47	3						21.24	15.780
18	9	0	42	2	5.292	5.040	0.252	19	9 1/2	19.68	14.250
	8	0	37	3							
12	9	0	34	3	4.623	4.403	0.220	20	10	17.73	12.260
	8	6	33	1						17.80	12.640
	7	6	29	1						17.86	13.301
9	9	0	31	0	4.200	4.000	0.200	21	10 1/2	16.80	11.340
	8	6	29	2						16.84	11.680
	7	6	26	2						16.90	12.233
	7	0	25	1						16.94	12.680
6	8	6	23	3	3.668	3.498	0.170	22	11	15.00	9.840
	8	0	22	2						15.05	10.180
	7	6	21	1						15.08	10.520
	7	0	20	1						15.11	10.860
	6	6	18	2						15.15	11.200
	6	0	17	3						15.20	11.540
								Inches	Inches		
4	5	0			3.204	3.053	0.151	4.469	2.208	12.004	7.620
3	4	6			2.913	2.775	0.138	4.005	2.003	10.923	6.919
Guns for Land Service											
12	6	0	24	0	4.623	4.403	0.220	5.780	2.888	16.183	10.399
	6	0	21	0				5.480	2.738	15.583	10.099
9	5	6	18	0	4.200	4.000	0.200	5.280	2.620	14.740	9.440

Construction

On a line given AB respresenting the axis of the piece, the number of feet and inches, of the given length of the piece are set off; and on each side of it, parallels EF, CD are drawn, at the distance of half a calibre, which will represent the bore.

The length of the gun is divided into seven equal parts, two of which are for the length of the first reinforce Ab: 1/7 plus one diameter of the calibre, for the second reinforce bd; and 1/5 of the remaining part dB is given to the length of the muzzle Be.

The thickness of metal AS from the extremity of the breech to the bottom of the bore, as likewise that of Ra which is equal to AS, is given in the table of a gun of that nature, and in the same manner, the half of that dimension is given to the neck ki; A line drawn through a and i produced towards t will describe the outline of the chace.

The outlines of the reinforces are determined in the following manner, make bn equal to Aa bisect mn in l, join al which will be for the outer surface of the first reinforce; take dr equal to bm, bisect pr in q and join lq, which will be the exterior surface of the second reinforce.

The axis of the trunnions is determined by a line drawn from the 3/7 of the pieces length, perpendicular to the axis of piece; their diameters are one calibre and lengths the same, clear of the projection of the second reinforce ring; and the centre of the trunnion is place half a calibre below the axis of the piece.

The bottom of the bore is made semi-elliptical, described from the several centres O, P, z, the first O is at the distance of 1 calibre from S the bottom of the bore, and those P and z are distant of 3 parts from g and y, taken in the line gy passing through f of 1/4 of the calibre from the bottom of the bore and perpendicular to the axis of the piece.

The outline of the breech aw is concentric with the arc TQ of the bottom of the bore, described with the radius Oa.

One eighth an divided into 3 equal parts, gives the base ring and its two mouldings au.

The outline of the breech is joined to the projection of the base ring by a small arc wx.

The breadth of the first and second reinforce rings, and all the astragals comprehending their fillets, are respectively equal to that of the base ring.

The second reinforce ogee is equal to 3/4 of its ring.

The projection of the second reinforce ring is equal to 1/2 of a fillet.

The projection of the base ring is 2 parts of the calibre, and a line drawn from its surface to that of the second reinforce ring, determines the projection of the first reinforce ring.

The projection of the mouldings, are half the breadth of the fillets.

The vent field uv is 1 calibre. The breadth of the pan is 2 1/2 inch, and thickness equal to the swell of the ogee, and extends from the centre of the ogee, to that of the vent astragal.

The vent is one fifth of an inch in diameter, and takes its direction from a point in the axis of the piece at one fourth of the calibre from the bottom of the bore, meeting the exterior surface of the pan, at the intersection made by a line drawn from the bottom of the bore perpendicular to the axis of the piece.

Cascable

The bottom of the cascable is constructed from the scale of the calibre; the diameter 1, 2 of the neck fillet is 22 parts, and that of the neck 3, 4 one calibre; it is described with a radius of 6 parts, meeting the outlines of the bore produced, the small arcs adjoining the neck are described with a radius of 3 parts, from centres taken in the produced lines of the bore; the end of the button is described with a radius of 12 parts, joining the last mentioned two small arcs, from a centre taken in the axis of the piece. The position of the button fillet is determined by the centres of the small arcs, and the breadth of the fillets are equal to those of the astragals.

The diameter 6, 7 of the hole for the breeching loop is half a calibre and its thickness 6, 8, 2/3 of its diameter. It is placed so as that the circumference of the hole shall meet the neck fillet and touch the arc of the circle describing the breech in one point, its position is in a vertical plane, with the axis of the piece, when the trunnions are in a horizontal situation. [A more particular construction may be obtained from the description given on its page 42. (See section ahead called "Construction of the Casable...")]

Muzzle

The length Be of the muzzle is equal to 1/5 Bd, the length of the chace. The distance BN from the face of the piece to the centre N of the swell is 1/5 Be the length of the muzzle, divided into three equal parts, for the muzzle mouldings. The diameter of the swell of the muzzle is so proportioned, to that of the base ring, as to admit a dispart of 1 1/2 degree of elevation; the arcs L, M, K are described with a radius of 1/4 KL; and the cavetto or hollow GH is described with a radius equal to twice GH.

Note. To reduce the diameter of the base ring and that of the swell of the muzzle, of each nature of gun given in Inches, into parts relative to the diameter of the calibre, as given in the table of iron guns page 35 [see table pg. 421], in which the diameter of the calibre according to the annexed construction, is divided into 16 equal parts. Divide 16 by the number of inches in the given calibre, and the quotient will be the number of parts contained in one inch, which being multiplied by the given diameter in inches, the product will be the required parts.

Example

To find in parts, the diameter of the base ring of a 42 pounder, answering in the table to 23.26 inches. Divide 16 by 7.018 and the quotient 2.2798 will be the number of parts contained in one inch, which being multiplied by 23.26 in. that is 23.26 x 2.2798, the product 52.028 will be the diameter of the base-ring in parts. [This is an error; product should be 53.028].

The diameter of the swell of the muzzle of the 42 pounder, being 17.46 inches. Multiply 17.46 by 2.2798, and the product 39.805 will be the diameter of the swell of the muzzle in parts.

The same rule is made use of, the diameter of the calibre being divided into any other number of parts, as for instance, into 32, 64, or 100 equal parts.

Construction of the cascable of an iron 12 pounder. Pl. 5

Make a decimal scale of inches, in the proportion of 1 1/2 foot to 10 inches, and from this scale make that of the calibre = 4.623 inches, divided into 16 equal parts.

Lengthways through the middle of the paper draw a line AB representing the axis of the piece, and on each side of it draw parallels at the distance of 8 parts. Make AC equal to 48 1/2 parts and through C draw DE perpendicular to AB.

Describe the base moulding, the vent field, the bottom of the bore &c as shown in the construction pl. 4. and according to the dimensions laid down in pl. 5.

From G as a centre and with GD as a radius describe the arc DHIE for the outer surface of the breech, take Dr equal to 5 parts, from r as a centre and with rD as a radius describe the arc DO.

Of Carronades and Cannonades

The construction of Carronades and Cannonades is obtained from the drawings which are in one of my portfolios, and from the dimensions given in the table page 425.

As a piece of ordnance is generally constructed from a scale of the diameter of the calibre, divided into 16 equal parts, the same may likewise be constructed, from a scale of the diameter of the calibre divided into 100 equal parts. The centesimal divisions of this scale being obtained according to prob. 11 sect 1st practical geometry.

When required to reduce arithmetically into hundredths, any given number of 16ths; find first how many 100ths there will be contained in 1/16. Divide 100 by 16 and the quotient will be 625 [6.25] then this quotion [sic] being 100ths it is written 0.0625. Wherefore any number of 16th of a piece of ordnance being multiplied by 0.0625 the product will be the required number in hundredths.

Suppose for example the thickness of metal at the breech of a gun to be 12/16, multiply 12 by 0.0625 and the product 0.7500, or 0.75 will be the required thickness of metal in hundredths.

Should the construction of a piece be made from a scale of the diameter of the calibre divided into 32 equal parts, and these parts required to be reduced into hundredth, divide 100 by 32 and the quotient will be 0.03125 = 1/32. If the diameter is divided into 64 equal parts, to reduce 1/64 into 100th proceed in the same manner by dividing 100 by 64 and the quotient 0.015625 will be the number of 100ths in 1/64 of the diameter of the calibre.

RAI, Landmann, "Notes on Artillery," circa 1790.

Construction of Carronades and Cannonades

	Nature and length of guns			Weight of Piece		Diameter			Thickness of metal			Weight of powder					
						Calibre	Shot	Windage	Before base ring	Breech	Muzzle Astragal	Proof		Service		Scaling	
Ordnance	Pounder	Feet	In	C^{wt}	Q	Inches	Inches	Inches	Inches	Inches	Inches	lb	oz	lb	oz	lb	oz
	68	5	0.693	36	1	8.05	7.9	0.150				13	0			2	0
	42	4	3.719	22	1	6.84	6.684	0.156	5.95		3.16 Neck	9	0			1	8
	32	3	11.71	17	2	6.25	6.105	0.145	5.50		2.85	8	0			1	4
Carronades	24	3	7.4	13	1	5.68	5.547	0.133	4.96			6	0			1	0
	18	3	3.26	9	3	5.16	5.040	0.120	4.60		2.40	4	0			1	0
	12	2	8.361	6	0.74	4.52	4.403	0.117	3.95		2.12	3	0			0	12
	24	6	0	31	2	5.823	5.547	0.227	6.308	6.200	3.100	8	0	4	0	1	0
	18	5	6			5.292	5.040	0.252	5.533	5.600	2.800	6	0	3	0	1	0
Cannonades	12	5	0			4.623	4.403	0.220	4.750	4.900	2.450	4	0	2	0	0	12
	9	4	6			4.200	4.000	0.200	4.740	4.475	2.237	3	0	1	8	0	8
	6	4	0			3.668	3.498	0.170	4.132	3.900	1.950	2	0	1	0	0	6

APPENDIX O. Shell-Guns.

	Length		Weight	Cal.	When
Type	ft.	in.	cwt.	in.	introduced
8-inch	5	8	36	8.05	obscure
	6	8.5	50	8.05	1825 (tested 1820)
	8		52	8.05	1840
	8		54	8.05	early 1860s
	8	6	60	8.05	1839
	8	10	60	8.05	1831
	9		65	8.05	1838 (1834?)
10-inch	7	6	57	10.0	1829 never
	8	4	62	10.0	1829 accepted
	9	4	84	10.0	1824
	9	4	86	10.0	1846
12-inch	8	4	90	12.0	1828 (only 1 cast)
	9	2	90	12.0	obscure

Source: Compiled from various shell-gun sources including Hogg and Batchelor, *Naval Gun*, 1978; Robertson, *Artillery Through the Ages*, 1971; Douglas 1860; RMC, Mould, 1825; Spearman 1844; and Straith, 1841.

Appendix P. Carronades, 1779–1870

	length			weight			ratio of weight of 1 lb. shot to total weight of caronade	calibre[o]	windage	
	ft.	in.	cal.	cwt.	qr.	lb.		in.	1810[p] in.	1865-6[q] in.
6 pdr.[a]	2	9	9.167	4	3		88.667	3.6	.12	.05
9 pdr.	4		11.650	8			99.555	4.12[b]	.12	?
12 pdr.	2	2[c]	5.752	5	3	10	54.5	4.52	.12	.056
	2	8[d]	7.080	6			56.	4.52		
18 pdr.	2	4[e]	5.426	8	1	25	52.722	5.16	.12	.061
	3	3	7.558	9			56.	5.16		
	3	4[f]	7.752	10			62.222	5.16		
24 pdr.	3[g]		6.338	11	2	25	54.708	5.68	.14	.068
	3	7 1/2	7.658	13			60.667	5.68		
	3	9[h]	7.922	13			60.667	5.68		
32 pdr.	4	01/4[i]	7.720	17	0	14	59.937	6.25	.15	0.73
	4[j]		7.680	17			59.5	6.25		
42 pdr.	4	3 1/2	7.529	22	1		59.333	6.84	.15	0.78
	4	4[k]	7.602	22	1		59.333	6.84		
	4	6[l]	7.895	22			58.667	6.84		
68 pdr.	4[m]		5.963	29			47.765	8.05	.15	.125
	5	2	7.702	36			59.294	8.05		
	5	4[n]	7.950	36			59.294	8.05		
12 - 68 pdr.			Average length in calibres				average ratio shot /weight			
short			5.87				52.424			
long			7.67				59.243			

Appendix P. Notes

a RMC, Mould, op. cit., p. 317, gave length of 2 ft. 8 in.; Spearman, (1844), op. cit., and Owen and Porter, op. cit., p. 66, gave weight of 5 cwt.

b Calculated, if windage is .12 in. and shot is 4 in. in diameter.

c Last reference, Adye, (1813), op. cit., p. 88.

d Straith, (1841), op. cit., p. 20 and Boxer, op. cit., plate XXX gave length of 2 ft. 8.361 in.; *Aide-Mémoire*, op. cit., Vol. I, pp. 60-1, gave length of 2 ft. 8.36 in.; Boxer and *Aide-Mémoire* give weight of 6 3/4 cwt.

e Last reference, Straith, (1841), op. cit., p. 20.

f First reference, Griffiths, (1847), op. cit., p. 69; *Aide-Mémoire*, op. cit, Vol. I,. p. 60 gave the length of 3 ft. 3.25 in. but Vol. II, p. 522, gave it of 3 ft. 4 in.; Boxer, op. cit., plate XXX gave length of 3 ft. 3.26 in.

g Last reference, Straith, (1841), op. cit., p. 20.

h First reference, Griffiths, (1839), op. cit., 1839, p. 51; *Aide-Mémoire*, op. cit., Vol. I, pp. 60-1, and Boxer, op. cit., plate XXX, gave length of 3 ft. 7.4 in. while RMC, Mould, op. cit., p. 317, and Owen and Porter, op. cit., p. 66, said 3 ft. 8 in.

i Last reference, Adye, (1813), op. cit, p. 88.

j First reference, RMC, Mould, op. cit., p. 317; Spearman, (1844), op. cit., *Aide-Mémoire*, op. cit., Vol. I, pp. 60-1, and Boxer, op. cit., plate XXX, gave length of 3 ft. 11.71 inches.

k First reference, RMC, Mould, op. cit., p. 317.

l First reference, Griffiths, (1847), op. cit., p. 69; Lefroy, (1867), op. cit., p. 72, and Owen and Porter, p. 66, gave length of 4 ft. 5 in.

m Last reference, Straith, (1841), op. cit., p. 20.

n First reference, Griffiths, (1847), op. cit., p. 69.

o Slight variations of calibres which may have existed before 1800 are not given.

p William Müller, *The Elements of the Science of War...* (London: Longman,, Hurst, Rees, Orme and Co., 1811), Vol. I, p. 84.

q Lefroy, (1867), op. cit., pp. 71-3.

Appendix Q. Dimensions of Common Standing Garrison Carriages in Use in 1748

Nature of Gun (pr.)		42	32	24	18	12	9	6	3
Width enclosed	before	18	18	16.5	15.5	14	13	11.5	9
	behind	23.5	23.5	22.5	21.5	19.5	18.5	16.8	12.5
Fore axletree	length	57	57	54.5	51.5	45.5	42.5	38.8	32.5
Body	length	35.4 **	36.6	34.9	33.1	29.5	27.5	24.8	19.5
	height	10.8	10.8	10	10	10	9.5	9	8.5
	breadth	6.8	6.8	6.8	6	5.5	5.2	5	4
Arms	length	10.8	10.2	9.8	9.2	8	7.5	7	6.5
	diameter	6.2	6.2	6.2	5.8	5.2	5	4.5	3.5
Hind axletree	length	57	57	54.5*	51.5	45.5	42.5	38.8	32.5
Body	length	35.4 **	36.6	34.9	33.1	29.5	27.5	24.8	19.5
	height	6.8	6.8	6.8	6	5.5	5.2	5	4
	breadth	12	12	12	12	12	12	12	12
Arms	length	10.8	10.2	9.8	9.2	8	7.5	7	6.5
	diameter	6.2	6.2	6.2	5.8	5.2	5	4.5	3.5
Fore trucks	diameter	19	19	18	18	16	16	14	14
	breadth	6.5	6	5.5	5	4.5	4	3.5	3
Hind Trucks	diameter	16	16	16	15	14	14	12	10
	breadth	6.5	6	5.5	5	4.5	4	3.5	3
Brackets	height before	26.8	26.2	26	23.6	20	18.8	16	13.6
	length	78	78	72	69	66	63	60	37.5
	breadth	6.5	6	5.5	5	4.5	4	3.5	3
Trunnions from the head		8	8	8	8	6.8	6.6	6.6	6
Steps+	height	2.7	2.6	2.6	2.5	2	1.10	1.6	1.3
	length	9.8	9.8	9	8.3	8.2	8	7.5	4.6

** Adye gives 36.6

* Adye, Muller, and Smith give 54 inches, but in all other carriages the lengths of the fore and hind axletree are the same.

+ Given only in Adye. The length is close to the formula of 1/2 the length divided by 4, but the height is considerably less than 1/2 the height divided by 4.

Adapted from John Muller, Treatise of Artillery, (London, 1780), p. 96; RAI, Adye (1766), pp. 40-1; George Smith, An Universal Military Dictionary .... (London, 1779), p. 51.

Appendix R. Table of Iron Work on Common Standing Garrison or Ship Carriage

Iron Work	No.
Cap squares	2
Eye bolts	2
Joint bolts	2
Transom bolt	1
Bed bolt	1
Bracket bolts	2
Hind axletree bolts	4
Breeching bolts with rings	2
Burrs	2
Loops	6
Dowel pins	4
Square rivetting plates	8
Rings with keys	10
Traversing plates	2
Linch pins	4
Axletree hoops	2
Axletree stays	2
Keys, chains, and staples	2
Stool bed bolts with rivetting plates	2
Axletree clouts (copper)	4

Notes:

1. Burrs were washers placed around the ends of bolts to be riveted.
2. Loops attached to the transom and the rear axletree may be for sea service. They were not shown by Rudyerd. Also Rudyerd showed only one loop on each side, not two.
3. The Dowel pins were wood not iron.
4. The square riveting plates were associated with the loops and the two breeching bolts and rings, the latter for sea service.
5. Rings with keys — these appear to be misnamed. Keys were inserted into the slots in the ends of some bolts.

Sources: RAI, Adye (1766), pp. 42-3; Muller, Treatise on Artillery, p. 99; Smith, An Universal Military Dictionary ..., p. 51.

Appendix S. The Construction of a Common Standing Garrison Carriage According to John Muller, 1750-1780

In a line AB, take two points C, D, so as their interval be equal to the distance from the center of the trunnions to the extremity of the breech, that is, equal to three sevenths of the gun's length; through these points draw two lines at right angles to AB; in the first take CE, CF, each equal to half the diameter of the second reinforce ring; and in the second DG, DH, each equal to half the diameter of the base ring; then the lines drawn through the points E, G, and F, H, will determine the width within of the carriage.

If to these lines there be drawn two parallels at a caliber's distance, they will determine the breadth of the side pieces; and by setting off from D to B, the length of the cascable, and from C to A, half the diameter of the trunnions and half the diameter of the fore trucks; then will AB be the length of the carriage.

The line EF passes through the centre of the trunion holes, which are a caliber, and whose center is a quarter of an inch below the upper surface of the side pieces. On each side of GH set off 6 inches for the breadth of the axletree, which is always 12 inches broad; and the fore part of the trunion holes is the centre line of the fore axletree, whose dimensions, as well as those of the trucks, are given in the following table (See Appendix Q).

The height of the side pieces is 4 3/4 diameters of the shot before, and half that height behind; and if half the length of the side pieces be divided into four equal parts, beginning at the hind end, you will have the steps; the quarter-round is taken from the fore part. The lower part of these pieces is hollowed in the form of a circular arc, in order to make them something lighter without diminishing their strength. Both axletrees are sunk into the side pieces in the manner represented in the 17th figure; and as to the transom, we chose to place it directly over the fore axletree, it is a diameter of the shot broad, and two high, and placed exactly in the middle of the height of the side pieces: though it is customary to place the fore part in a line passing through the center of the trunion holes, and so as to project the axletree by an inch, and the lower edge to touch the axletree.

Source: Muller (1780), Treatise on Artillery, pp. 95-6.

Note: This formula is more or less repeated in Abraham Rees, The Cyclopaedia... (London, 1819), Vol. 6, "Carriages," with the following additional piece of information:

> Each of these side pieces is hollowed or cut out beneath, in the form of a circular arc, of which the radius is about half the length of the piece.

Appendix T. Dimensions of Common Standing Garrison Carriages, 1801

Calibre	32		24		18		12		9		6	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Axletrees, length	4	9	4	7	4	3	3	9.5	3	6.5	3	4
Side pieces, length	6	4	6	0	5	9	5	6	5	3	5	0
Whole height to trunnion beds	2	9	2	7	2	6	2	3	2	1	2	0
Weight of Carriage, bed and coins, cwt.	9		8		7		6		3.75		2.75	

Adye (1801), p. 58

Dimensions of Stool for Beds Common Standing Garrison Carriages, 1801-13

	Length		Breadth Inches			Height Inches
	Ft.	In.				
42 Pounder	2	10	11	to	8.75	3.75
32 Pounder	2	10	10	to	5.50	3.25
24 Pounder	2	9	10.25	to	6.50	4
18 Pounder	2	8	9.50	to	6.50	3.75
12 Pounder	2	8	10	to	6.50	4
9 Pounder	2	7	9.50	to	5.75	3.50
6 Pounder	2	6	9	to	4.75	3.50
4 Pounder	2	6	8.25	to	5.25	3

Adye (1801), op. cit., p. 35 and (1813), op. cit., p. 63.

Appendix T. Dimensions of Common Standing Garrison Carriages, 1813

Calibre	42		32		24		18		12		9		6	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Axletree, total length	5	0	4	10	4	6.5	4	5	4	1	4	0	3	10
Depth														
Fore		11		11		11		10.5		10.5		10.5		9.5
Hind		7.75		7.75		6.75		6.75		6.75		6.75		5.75
Thickness														
Fore		7.75		7.75		6.75		6.75		6.75		6.75		5.75
Hind		7.75		7.75		6.75		6.75		6.75		6.75		5.75
Width	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Length of Bracket	6	5	6	3	6	2	6	1	5	9	5	8.25	5	7
Thickness of Bracket		6		6		5.5		5		4.5		4		3.25
Depth of Bracket	2	3	2	2.5	2	2	2	1	2	1	2	0	2	0
Width														
before	1	6.75	1	5.5	1	4.75	1	3.75	1	1.875	1	0.875		11.75
behind	2	0.5	1	11.75	1	11	1	9	1	7.5	1	6.5	1	5.25
Diameter of trucks														
Fore	1	6.75	1	6.75	1	6.75	1	6.75	1	6.75	1	6.75	1	6.75
Hind	1	3.75	1	3.75	1	3.75	1	3.75	1	3.75	1	3.75	1	3.75
Diameter of arm of axle 1/4 of an inch less than bore of truck		7.5		7.5		7.5		6.5		6.5		6.5		5.5
Weight of carriage, bed,	C. Q.	Lb.	C. Q.	Lb.	C. Q.	Lb.	C. Q.	Lb.	C. Q.	Lb.	C. Q.	Lb.	C. Q.	Lb.
trucks, and coins	16 3	13	15 1	0	13 2	0	12 3	0	11 3	0	10 1	0	9 1	0

Adye (1813), op. cit., p. 92. The dimensions have been printed as given but those for the axletree — depth, thickness, and width — do not make sense.

Appendix U. Dimensions of Common Standing Garrison Carriages, 1828 and 1844.

Calibre	42		32		24		18		12		9		6		4		3	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Brackets																		
Top																		
Length	5	7.5	5	5.75	5	4.75	5	2.5	5	0.5	5		4	11.0	3	11.0	3	4.0
Depth	1	1.5	1	1.25	1	1.0	1	0.5	1	0.5	1		1			9.5		9.5
Bottom																		
Length	6	5.0	6	3.25	6	2.0	5	11.5	5	9.0	5	8.5	5	7.75	4	6.0	3	9.0
Depth	1	1.5	1	1.25	1	1.0	1	0.5	1	0.5	1		1			9.5		9.5
Thickness		6.5		6.0		5.5		5.25		4.5		4.25		3.75		3.75		3.25
Transom																		
Length	1	9.0	1	8.5	1	7.5	1	7.0	1	4.0	1	4.0	1	3.0	1	1.0	1	1.0
Depth	1	5.0	1	4.75	1	4.75	1	4.0	1	4.5	1	4.0	1	3.75	1	0.5	1	0.5
Thickness		6.5		6.0		5.5		5.25		4.5		4.25		3.75		3.5		3.25
Axletrees																		
Fore																		
Length of bed	3	1.5	3	0.5	2	11.0	2	10.0	2	6.0	2	5.0	2	4.0	1	10.0	1	10.0
Breadth		7.75		7.75		6.75		6.75		6.75		6.75		5.75		5.75		5.75
Depth		11.0		11.0		10.5		10.5		10.5		10.5		9.5		6.5		6.5
Hind																		
Length of bed	3	1.5	3	0.5	2	11.0	2	10.0	2	6.0	2	5.0	2	4.0	1	10.0	1	10.0
Breadth		12		12		12		12		12		12		12		11		11
Depth		7.75		7.75		6.75		6.75		6.75		6.75		5.75		5.75		5.75
Length of arm		10.75		10.75		9.75		9.5		9.5		9.5		9.0		9.0		9.0
Diameter of arm		7.5		7.5		6.5		6.5		6.5		6.5		5.5		5.5		5.5
Trucks																		
Fore																		
Diameter	1	7	1	7	1	7	1	7.75	1	7.75	1	7.75	1	6.25	1	6.25	1	6.25
Diameter of Hole		7.5		7.5		6.5		6.5		6.5		6.5		5.5		5.5		5.5
Width of sole		6.625		6.625		5.0		5.0		5.0		5.0		4.25		4.25		4.25
Hind																		
Diameter	1	4.0	1	4.0	1	4.0	1	4.0	1	4.0	1	4.0	1	4.0	1	4.0	1	4.0
Diameter of hole		7.5		7.5		6.5		6.5		6.5		6.5		5.5		5.5		5.5
Width of sole		5.0		5.0		4.5		4.5		4.5		4.5		3.5		3.5		3.5
Stool-Bed																		
Bed																		
Length	2	11.0	2	11.0	2	10.0	2	8.5	2	8.5	2	8.5	2	8.0	2	3.0	2	3.0
Breadth, greatest		11.0		10.0		10.0		9.5		9.5		9.5		8.0		8.5		8.5
least				6.5		6.5		6.0		6.0		6.0		5.0				
Thickness		4.5		4.25		4.25		4.25		4.0		4.0		3.5		3.5		3.5
Stool																		
Length	1	3.0	1	5.0	1	4.0	1	3.0	1	3.0	1	1.0	1	1.0		11.0		11.0
Breadth		9.0		9.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0
Thickness		4.75		4.75		4.5		4.5		4.5		4.5		4.0		4.0		4.0
Quoins																		
Breadth, greatest		10.75		10.75		9.5		9.25		9.25		9.75		9.25		8.25		8.25
least				6.5		6.25		5.75		5.75		6.0		5.5				
Length	2	3.0	2	3.0	2	0.75	2	0.75	1	11.0	1	10.0	1	8.0	1	6.0	1	6.0
Thickness, greatest		6.75		6.75		6.75		6.75		6.25		6.0		5.75		6.0		6.0
least				2.75		2.75		2.75		2.75		2.5		2.5				

Adapted from Spearman, The British Gunner (1828), pp. 48-9, 112, 342-3, 386-7, 401 and (1844), "Car." unpaginated. The two sets of tables are not identical, that of 1844 does not given any dimensions for the 42-, 4-, or 3-pdrs. The table of 1844 gives least breadth and thickness of the quoin and of the bed of the stool-bed; this has been included in the table above. The table of 1844 gives the diameter of the fore trucks of the 24- to 9-pdr. inclusive as 1 ft. 6.75 in., also the greatest breadth of the coin of the 12-pdr. as 9.5 inches.

Appendix V. Dimensions of Iron Trucks for Common Standing Garrison Carriages, 1839-62

	Fore							Hind						
	Diameter Truck		Hole	Width of Sole	Weight of two			Diameter Truck		Hole	Width of Sole	Weight of two		
	Ft.	In.	in.	in.	cwt.	qr.	lb.	Ft.	In.	In.	In.	cwt.	qr.	lb.
42	1	7	7.5	6.62	3	0	20	1	4	7.5	5	2	0	4
32	1	7	7.5	6.62	3	0	20	1	4	7.5	5	2	0	4
24	1	7	6.5	5	2	1	26	1	4	6.5	4.5	1	2	5
18	1	7	6.5	5	2	1	26	1	4	6.5	4.5	1	2	5
12	1	7	6.5	5	2	1	26	1	4	6.5	4.5	1	2	5
9	1	7	6.5	5	2	1	26	1	4	6.5	4.5	1	2	5
6	1	6	5.5	4.25	1	3	4	1	4	6.5	3.5	1	1	6
3	1	6	5.5	4.25	1	3	4	1	4	6.5	3.5	1	1	6

Adapted from Griffiths, The Artillerist's Manual..., (1839), p. 62 (1840), p. 69, (1847), p. 77, (1852), p. 68, (1859), p. 71, (1862), p. 73. In 1839 the diameter of the fore trucks of the 42- to 9-pdr. inclusive was said to be 1 ft. 7-3/4 in., but thereafter 1 ft. 7 in.

Appendix W. Dimensions of Stool Beds and Quoins, 1839-62

Stool Beds

	Beds						Blocks					
	Length		Breadth		Thickness		Length		Breadth		Depth	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
42	2	11		11		4.5	1	5		4.75		9
32	2	11		10		4.25	1	5		4.75		9
24	2	10		10		4.25	1	4		4.5		8
18	2	10.2		9.5		4.25	1	3		4.5		8
12	2	10.2		9.5		4	1	3		4.5		8
9	2	10.2		9.5		4	1	1		4.5		8

Adapted from Griffiths, The Artillerist's Manual..., (1839), p. 80, (1840), p. 93, (1847), p. 101, (1862), p. 99

Quoins

	Length		Width	Thickness
	Ft.	In.	In.	Ft.
42	2	3	10.75	6.75
32	2	3	10.75	6.75
24	2	9	9.5	6.75
18	2	9	9.5	6.75
12	1	11	9.25	6.25
9	1	11	9.15	6

Adapted from Griffiths, op. cit., (1839), p. 79, (1840), p. 88, (1847), p. 96, (1862), p. 96

Appendix X. Dimensions of Common Standing Garrison Carriages, circa 1864.

	Brackets						Axletrees, Wood							
	Length		Width		Depth		Length between Shoulders		Length of Arm		Diameter of Arm		Depth of Axle-tree	Width of Axle-tree
	ft.	in.	ft.	in.	ft.	in.	Front in.	Hind in.	Front in.	Hind in.	Front in.	Hind in.	Front in.	Hind in.
8-inch, 65 cwt. Gun	6	0		6	2	3	35 1/2	37	10	10	7 1/4	7 1/4	10	12
24-pdr., 50 cwt. Gun	6	2 1/2		5 1/2	2	1 1/2	35 1/2	35 1/2	10	10	7 1/4	6 1/4	10	12
18-pdr., 42 cwt. Gun	5	11		5	2	0 1/4	35 1/2	36	10	10	6 1/4	6 1/4	10	12

	Trucks					
	Diameter		Width of Sole		Diameter of Hole	
	Front in.	Hind in.	Front in.	Hind in.	Front in.	Hind in.
8-inch, 65 cwt. Gun	19	16	6 1/2	5 1/4	7 1/2	7 1/2
24-pdr., 50 cwt. Gun	19	16	6 1/2	4 1/2	7 1/2	6 1/2
18-pdr., 42 cwt. Gun	20	16	5	4 1/2	6 1/2	6 1/2

"For the 24-pounder the axletree is 7 1/2 inches in diameter in front, and 6 1/2 inches in rear. Above that size, and up to the 56-pounder, both axletrees are 7 1/2 inches, and for the 56-pounder and upwards they are both 8 1/2 in diameter. (p.16).

"The trucks are of cast iron, those in front have a diameter of 19 inches and a width of sole of 6 inches; the rear trucks are 16 inches in diameter and 4 1/2 inches wide in the sole." (p.17)

There is a conflict between these two statements and the tables which has not been reconciled.

PRO, Supply Department Records, Supp. 5, 76, "Notes on Manufactures of the Royal Carriage Department," p. 31.

Appendix X. Dimensions of Common Standing Garrison Carriages, *circa* 1864.

Trucks	Front				Hind			
	Diameter in.	Sole in.	Hole in.	Weight lb.	Diameter in.	Sole in.	Hole in.	Weight lb.
8-in., 42-pr., 32-pr.	19	6 1/2	7	178	16	5	7	114
24-pr. to 9-pr.	19	5	6 1/2	139	16	4 1/2	6 1/2	87
6-pr.	18	4 1/4	5 1/2	100	16	3 1/2	6 1/2	73

Miller, *Equipment of Artillery* ... (London, 1864), p. 385.

Appendix Y. Dimensions of Rear Chock Carriages, circa 1864.

	Brackets							Axletrees, Wood							Trucks				
	Length		Width		Depth		Hind Block	Length between Shoulders		Length of Arm		Diameter of Arm		Depth of Axle-tree	Diameter		Width of Sole	Diameter of Hole	
	ft.	in.	ft.	in.	ft.	in.	in.	Front in.	Hind in.	Front in.	Hind in.	Front in.	Hind in.	Front in.	Front in.	Hind in.	Front in.	Front in.	Hind in.
68-pr., 95 cwt. or 10-in., 87 cwt.	6	8		6 1/2	2	6	52 x 18 x 11	38		11		8		11 1/2	19		6 1/2	8 3/4	
8-in., 52 cwt.	5	6		6	2	4	48 x 15 x 11 1/2	35 1/2		11		7 1/4		10	19		6 1/2	7 1/2	
8-in., 65 cwt.	5	11 1/2		6	2	3 3/4	49 x 13 x 6	35 1/2		10		7 1/4		10	19		6 1/2	7 1/2	
32-pr., 56 cwt.	6	3 1/2		6	2	2	49 x 12 x 6 1/4	35 1/2		10		7 1/4		11	19		6 1/2	7 1/2	
24-pr., 32 cwt.	5	0 1/2		4 1/2	1	11 1/2	30 1/2 x 12 x 6	30		9 1/2		6 1/4		7 1/2	20		5	6 1/2	
8-in., 22 cwt., How.	5	0 1/2		6	2	3 1/2	48 x 12 x 6	36		11		7 1/4		10	19		6 1/4	7 1/2	
10-in., How.	5	3 1/2		6	2	5 1/2	49 x 18 1/2 x 10	35 1/2		11		7 1/4		10 1/2	19		6 1/2	7 1/2	
5 1/2-in., How.	3	7 1/2		5	1	7 1/2	33 x 9 x 8	31 1/2		9		6 1/4		11	20		5	6 1/2	

PRO, Supply Department Records, Supp. 5, 76 "Notes on the Manufactures of the Royal Carriage Department," op. cit., p. 31.

Appendix Z. Dimensions of Sliding Carriages, circa 1864

	Brackets						Blocks	
	Length		Width		Depth		Front	Hind
	ft.	in.	ft.	in.	ft.	in.	in.	in.
10-in. 87 cwt. Dwarf	6	6		6 1/2	2	7	46 x 15 x 8	48 x 20 x 9
68-pr. Casemate	6	6		6 1/2	2	0	45 x 15 x 8	48 x 20 x 9
68-pr., 95 cwt.	6	6		6 1/2	2	7	48 x 15 x 8	48 x 20 x 9
56-pr., 98 cwt.	6	6 1/2		6 1/2	2	3	48 x 14 x 8	49 x 19-1/2 x 8-1/4
32-pr., 56 cwt.	6	1		6	2	3	45 x 12 x 7	45 x 18 x 9
24-pr., 50 cwt.	6	2		5 1/2	2	1 1/2	45 x 12 x 7	45 x 14 x 9
18-pr., 32 or 42 cwt.	6	0		5	2	3	45 x 12 x 6	45 x 18 x 8-1/2
8-inch, 60 or 65 cwt.	6	1		6	2	1 1/2	45 x 12 x ?	45 x 18 x 9
8-inch, 52 cwt.	5	10		6	2	1 1/2	45 x 15 x 7	45 x 18 x 9

PRO, Supply Department Records, Supp. 5, 76 "Notes on the Manufactures of the Royal Carriage Department," op. cit., p. 31.

Appendix AA. Dimensions of Land Service Mortar Beds, 1750-80

Calibre		13 in. in.	10 in. in.	8 in. in.	5.8 in. in.	4.6 in. in.
Lower Bed	length	84	66	50	-	-
	breadth	33	26	20	-	-
	height	13	10	9	-	-
Upper Bed	length	83	65	49	31.5	28.5
	breadth	32	25	19	16	14
	height	13	12	11	10	9
Breadth of quarter round		3	2.5	2.5	-	-
Breadth of ogee & fillet		4	3.5	3	-	-
Length of cavity		20	16	12	8	5.7
Trunnion from the fore end*		31	20	15.5	13.3	11.7
Diameter of the trunnion hole		7.2	6.4	5.4	3.4	2.4
Depth of the trunnion hole		7	6	5	3.2	2.2

* The distance of the trunnion holes is measured from the quarter round and not from the end of the bed.

Iron work of 13-, 10-, & 8-inch beds

	No.
Cap squares	2
Eye bolts	2
Joint bolts	2
Under & upper bed bolts	9
Dowell bars	4
Rings with bolts	4
Reverse bars	2
End rivetting plates	2
Middle plate	1
Rivetting bolts	6
Square rivetting plates	12
Traversing bolts	6
Keys, chains, and staples	2

Iron work of a royal & coehorn bed

	No.
Cap squares	2
Eye bolts	2
Joint bolts	2
Rivetting bolt with ring	1
Handles with starts	2
Square rivetting plates	5
Keys, chains, and staples	2

Adapted from RAI, Adye (1766), pp. 60-2;
Muller Treatise of Artillery (1780), op. cit., pp. 119-20; Smith, An Universal Military Dictionary pp. 28-9.

Appendix BB. Dimensions of Iron Work for Wheels of Travelling Carriages, 1719

	24-pdr.			12-pdr.			6-pdr.			3-pdr.			1 1/2-pdr.		
	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.
Streaks															
Double hole			12												
length	2	5 7/8													
breadth		4 3/4													
thickness		5/8													
Single hole						12			12			12			12
length				2	5 7/8		2	4 1/2		2	4 1/2		2	2 2/3	
breadth					4			3 1/4			2 1/2			2	
thickness at edge					5/8			1/2			1/2			3/8	
thickness in middle					5/16			1/4			1/4			3/16	
Nails for															
Double streak			144												
shank's length		7 3/4													
shank's breadth		3/4													
shank's thickness		1/2													
diamond head's square		1 1/4													
diamond head's thickness		5/8													
Single streak						96			96			96			96
shank's length					7 1/4			6 1/4			5 1/4			4 3/4	
shank's breadth					3/4			5/8			1/2			1/2	
shank's thickness					1/2			3/8			3/8			3/8	
head's length					2 1/4			2 1/8			2			2	
head's breadth					1 1/4			1 1/8			1 1/8			1 1/8	
head's thickness at crown					5/8			1/2			1/2			1/2	
Dowledges															
Double hole			12			12									
length	1	4		1	3										
breadth		2 3/16			2										
thickness		2/5			2/5										
1st hole's centre from end		1			1										
2nd hole's centre from end		4			4										
Single hole									12			12			12
length								11			10			9	
breadth								1 5/8			1 1/3			1 1/8	
thickness								3/8			3/8			3/8	
hole's centre from end								1 1/8			1 1/8			1 1/4	
Rivets			48			48			24			24			24
length		5 1/2			4 3/4			4			3 1/4			2 3/4	
thickness		3/4			3/4			1/2			1/2			3/8	
head's diameter		1 1/2			1 1/2			1 1/4			1 1/4			1 1/8	

Nave hoops										
Fore		2		2		2		2		2
breadth	1 1/2		1 1/2		1 1/2		1 1/8		1 1/2	
thickness	3/8		3/8		3/8		3/8		3/8	
Middle		4		4		4		4		4
breadth	1 1/2		1 1/2		1 1/2		1 1/8		1 1/2	
thickness	3/8		3/8		3/8		3/8		3/8	
Hind		2		2		2		2		2
breadth	1 1/2		1 1/2		1 1/2		1 1/8		1 1/2	
thickness	3/8		3/8		3/8		3/8		3/8	
Stubbs		24		24		24		24		24
length	3		3		3		3		3	
thickness	1/4		1/4		1/4		1/4		1/4	
Body box		2		2		2		2		2
interior diameter	7		6 1/2		6		5 1/4		4 1/2	
length	3 1/2		3 1/4		3		3		2 3/4	
thickness	3/4		3/4		5/8		5/8		1/2	
Linch box		2		2		2		2		2
interior diameter	5 1/2		5		4 1/2		3 3/4		3	
length	3		2 3/4		2 1/2		2 1/2		2 1/4	
thickness	3/4		3/4		5/8		5/8		1/2	
Body box pins		6		6		6		6		6
length	5		5		5		5		5	
thickness	1/2		1/2		1/2		1/2		1/2	
Linch box pins		4		4		4		4		4
length	4 1/2		4 1/2		4 1/2		4 1/2		4 1/2	
thickness	1/2		1/2		1/2		1/2		1/2	

Note:

1) Streaks for 24-pdr. have a double row of holes, 12 holes per streak. For the others a single row of 8 holes.
2) Nails for double and single streaks are described differently.
3) The 24- and 12-pdr. dowledge each have 4 holes for the rivets; the remainder have only 2 holes each.
4) All naves have 4 hoops, one set at each end and 2 at the middle, presumably snug against the spokes. The interior diameter of the hoops is not given, but it would have to correspond to the nave dimensions.
5) The 1 1/2-pdr. has no limber.
6) The thickness of the single hole streaks seems to vary from edge to centre, presumably because there is more wear on the edge.

RAI, Borgard, Tables, op. cit., No. 36, 37, "Dimensions, Weight and Value of Iron-Work for Hind & Fore Wheels for Travelling-Carriages; according to the New Regulation By Colonel Albert Borgard in the Year 1719."

Appendix CC. Dimensions of Iron Work for Wheels of Limbers, 1719

	24-pdr.			12-pdr.			6-pdr.			3-pdr.		
	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.
Streaks												
Double hole												
length												
breadth												
thickness												
Single hole			12			12			12			12
length	1	11 5/8		1	11 5/8		1	11 1/8		1	11 1/8	
breadth		3 3/4			3 1/4			2 3/4			2 3/8	
thickness at edge		5/8			5/8			1/2			1/2	
thickness in middle		5/16			5/16			1/4			1/4	
Nails for												
Dougle streak												
shank's length												
shank's breadth												
shank's thickness												
diamond head's square												
diamond head's thickness												
Single streak			72			72			72			72
shank's length		6 1/2			6			5 1/8			4 5/8	
shank's breadth		5/8			5/8			1/2			1/2	
shank's thickness		3/8			3/8			3/8			3/8	
head's length		2 1/8			2 1/8			2			2	
head's breadth		1 1/8			1 1/8			1 1/8			1 1/8	
head's thickness at crown		1/2			1/8			1/2			1/2	
Dowledges												
Double hole												
length												
breadth												
thickness												
1st hole's centre from end												
2nd hole's centre from end												
Single hole			12			12			12			12
length		9			9			8 1/2			8	
breadth		1 5/8			1 3/8			1 1/4			1 1/8	
thickness		3/8			3/8			3/8			3/8	
hole's centre from end		1 1/4			1 1/4			1 1/8			1 1/8	

Rivets		24		24		24		24
length	4 3/4		3 3/4		3 3/8		3	
thickness	5/8		5/8		1/2		3/8	
head's diameter	1 3/8		1 3/8		1 1/4		1 1/8	
Nave hoops								
Fore		2		2		2		2
breadth	1 1/2		1 1/2		1 1/2		1 1/2	
thickness	3/8		3/8		3/8		3/8	
Middle		4		4		4		4
breadth	1 1/2		1 1/2		1 1/2		1 1/2	
thickness	3/8		3/8		3/8		3/8	
Hind		2		2		2		2
breadth	1 1/2		1 1/2		1 1/2		1 1/2	
thickness	3/8		3/8		3/8		3/8	
Stubbs		24		24		24		24
length	2 1/2		2 1/2		2 1/4		2 1/4	
thickness	1/4		1/4		1/4		1/4	
Body box		2		2		2		2
interior diameter	6 1/8		5 5/8		5 1/4		4 1/2	
length	3		2 7/8		2 3/4		2 3/4	
thickness	5/8		5/8		1/2		1/2	
Linch box		2		2		2		2
interior diameter	4 3/8		3 7/8		3 1/2		2 3/4	
length	2 3/4		2 5/8		2 1/2		2 1/2	
thickness	5/8		5/8		1/4		1/2	
Body box pins		6		6		6		6
length	4 1/2		4 1/2		4		4	
thickness	1/2		1/2		1/2		1/2	
Linch box pins		4		4		4		4
length	3 1/2		3 1/2		3		3	
thickness	1/2		1/2		1/2		1/2	

RAI, Borard, Tables, op. cit., No. 36, 37, "Dimensions, Weight and Value of Iron-Work for Hind & Fore Wheels for Travelling-Carriages; according to the New Regulation By Colonel Albert Borgard in the Year 1719."

Appendix DD. Dimensions of Wheels for Travelling Carriages, 1722

	24 pr.		12		6		3		1 1/2	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Wheels										
Total Height	4	9	4	9	4	6	4	6	4	3
Dishing		4		4		3 3/4		3 1/4		3 1/2
Nave										
Total Length	1	6	1	5	1	4	1	3	1	1
Pain Stroke's Length from y.^{e} Centre forw^{d}[?]		1		1		1		1		1
Greatest Height	1	5	1	4	1	3 1/4	1	1 1/2	1	0
D^{o}. behind	1	3	1	2	1	1 3/4	1	1		11
D^{o}. before	1	1	1	0 1/4	1	0 1/4		11		9 9
Beads Square from y^{e} Pain Stroke[?]		2		2		2		2		2
Fellows										
Length	2	5 5/8	2	5 5/6	2	4 1/3	2	4 1/3	2	2 2/3
Depth		6 1/2		6		5 1/2		4		3 1/2
Greatest Thickness at the womb		5 3/8		4 5/8		3 7/8		3 1/8		
D^{o}. Lesser		5		4 1/4		3 1/2		2 3/4		2 1/4
Spokes at y^{e}. Nave										
Length	2	1 1/2	2	2 1/4	2	1 1/4	2	1 1/2	2	
Depth		4		3 5/8		3 1/4		3		2 3/4
Thickness		2 1/4		2		1 3/4		1 1/2		1 1/4
Spokes at y^{e}. Fellows										
Depth		3 1/4		3		2 3/4		2		1 3/4
Thickness		2 1/4		2		1 3/4		1 1/2		1 1/4
Tongues Thickness		1 8/12		1 5/12		1 2/12		11/12		9/12
Dowil pins for Fellows										
Length		*		8 1/2		8		8		7 1/2
Thickness		*		*		1 1/8		1 1/8		1

*Indecipherable cit., p. 8.

RAI, James, op. cit., p. 8, "Dimentions and Draughts of Hind and Fore Wheels for Travelling Carriages. Regulated 1722."

Appendix EE. Dimensions of Wheels for Limbers of Carriages, 1722

	24 pr.		12		6		3	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Wheels								
Total Height	3	10	3	10	3	8	3	8
Dishing		3 1/4		3 1/2		3 1/2		3 1/2
Nave								
Total length	1	3 3/4	1	2 7/8	1	2	1	0
Pain Stroke's Length from y^{e} Center forw^{d} [?]		1		1		1		1
Greatest Height	1	2 7/8	1	2	1	1 1/4	1	0 3/8
D^{o}. behind	1	1 3/8	1	0 1/2	1	0 1/4		11
D^{o}. before		11 7/8		11 1/4		11		10
Beads Square from y^{e}. Pain Stroke [?]		2		2		2		2
Fellows								
Length	2	0 1/12	2	0 1/2	1	11 1/24	1	11 1/24
Depth		5		4 3/8		3 7/8		3 3/8
Greatest Thickness at the womb								
D^{o}. Lesser		4		3 3/8		3		2 5/8
Spokes at y^{e}. Nave								
Length	1	8 3/8	1	9	1	8 1/4	1	8 3/8
Depth		3 1/2		3 3/16		3		2 5/8
Thickness		2		1 7/8		1 1/2		1 1/4
Spokes at y^{e}. Fellows								
Depth		2 5/8		2 3/8		2 3/16		1 5/8
Thickness		2		1 7/8		1 1/2		1 1/4
Tongues Thickness		1 4/12		1 1/8		1		0 7/8
Dowil pins for Fellows								
Length		7 1/2		7 1/2		7		7
Thickness		1 1/8		1 1/8		1		1

RAI, James, op. cit., p. 8.

Appendix FF. Dimensions of the Wheels of Travelling and Field Carriages, 1750-80

Calibre	Travelling 24 in.	Travelling 12 in.	Travelling 6 in.	Travelling 3 in.	Field 24 in.	Field 12 in.	Field 6 in.
Diameter of the wheels	58	58	58	58	50	50	50
Length of the Nave	17.5	17	15.5	15*	15	13	12.7
Diameter of the Nave							
body	15	15	13	12.5	13	11	10.6
middle	16	16	14	13	14	12	11.6
linch	13.5	13.5	10	10	12	11	10
Fellows							
thickness	5	4.5	4	3	3.3	2.8	2.4
breadth	6.5	6	5.5	4.5+	4.7	4	3.6
Spokes							
thickness	2.3	2.2	2.1	2	2	1.8	1.7
breadth	4.5	4	3.5	3	3.5	3.2	2.9

* 12.5 and +5 in Smith.

RAI, Adye (1766), pp. 45-6, 50-1; Muller, Treatise of Artillery (1780), 108, 113; Smith, An Universal Military Dictionary, pp. 52-53.

The Iron Work of Wheels of Travelling Carriages

	No.
The Dowell Pins	6
The Streaks	6
The Streak Nails	48
The Nave Hoops	3
The Nave Boxes	2
The Dowledges	6
Rivets for Dowledges	24
Nave Hoop Stubs	9
Box Pins	6

"The Dowell Pins are wooden pegs, tho' by mistake included in the Iron Work, about three Inches long & three quarters of an Inch diameter & the Dowledges are Iron plates, fsten'd and sunk into the fellows on the outside."

RAI, Adye (1766), op. cit., pp. 47-8; Muller (1780), op. cit., p. 107; Smith, op. cit., p. 53.

Appendix GG. Dimensions of the Wheels for Limbers of Travelling and Field Carriages, 1750–80

Calibre	Travelling 24 in.	Travelling 12 in.	Travelling 6 in.	Travelling 3 in.	Field 24 in.	Field 12 in.	Field 6 in.
Diameter of the wheels	48	48	48	45	48	45	45
Length of the Nave	16	15	14	10	14	12	10
Diameter of the Nave							
body	13.5	13.5	12	12	12	10	12
middle	14	14	13	12.5	13	12.6	12.5
linch	12	12	11	10	11	10.5	10
Fellows							
thickness	4.5	4	3.5	3	3.5	3	3
breadth	5	4.5	4	3.5	4	3.5	3.5
Spokes							
thickness	1.8	1.6	1.4	1.2	1.5	1.5	1.5
breadth	4'	3.5	3	2.5	3	2.5	2.5

RAI, Adye (1766), op. cit., pp. 53–4, 56; Muller (1780), op. cit., p. 116; Smith, op. cit., p. 54. Only Adye gives the dimensions for the field carriage limber wheels

Appendix HH. Dimensions of Wheels, 1801, 1813, 1827

	Diameter Ft.	Diameter In.
All horse artillery carriages, limbers; Hy. 6-pr. and long 3-pr. and limbers; carriages of 6-pr. battalion guns & Lt. 5 1/2-inch howitzer	5	
Limbers to Lt. 6-pr. and 5 1/2-inch Howitzer	4	8
Med. 12-pr. carriage & limber	[4	8 ?]

Adye (1801), op. cit., p. 57.

Wheels (1813)	Height Ft.	Height In.	Length of Box Ft.	Length of Box In.	Diameter of Box Body In.	Diameter of Box Linch In.	Width of Tire In.	Weight of Two cwt.	Weight of Two qr.	Weight of Two lb.
Brass										
Heavy — 12-pr., 9-pr., Hy. 6-pr. guns Hy. 5 1/2-inch howitzer	5		1	2	3 1/8	2 1/16	2 3/4	4	0	26
Light-Lt. 6-pr. gun, Lt. 5 1/2-inch howitzer, Hy. 3-pr. gun	5		1	1	2 3/4	1 3/4	2 1/2	3	2	7
Light 3-pr. block trail carriage & limber, 1-pr. gun, 4 2/5-inch howitzer	4	4		11	2	1 1/2	2 1/4	1	3	20
Iron										
Limbers for 12-pr. iron gun, 9-pr. iron gun, 24-pr. iron howitzer	4	2	1	1	2 3/4	1 3/4	2 1/2	2	3	20
8-inch howitzer, 18 pr., 12-pr. of 9 ft.	4	10	1	5	6 1/2	5 1/2	4	6	2	7
Limbers of 8-inch howitzer, 24-pr., 18-pr., 12-pr. of 9 ft.	3	10	1	2	3 1/8	2 1/16	3 1/4	3	2	27
Carriage of 24-pr. of 50 cwt. or 9 1/2 ft.	4	10	1	6	7	5 1/2	5	7	1	2

Adye (1813), op. cit., pp. 390-1.

8-inch howitzer, 18-pr., 12-pr. of 9 ft.	5		1	4	3 1/2	2 1/2	4	6	2	7
Limbers of 8-inch howitzrer, 24-pr., 18-pr., 12-pr. of 9 ft.	3	10	1	2	5 1/8	2 1/16	4 1/4	3	2	27
Carriages of 24-pr. of 50 cwt. or 9 1/2 ft., 10-inch howitzer	5		1	6	3 3/4	2 3/4	5	7	1	2

Adye (1827), op. cit., pp. 392-3. This table is similar to that of 1813; only the last three items are copied, in which there were some changes. The other items remained unchanged.

Appendix II. Dimensions of Wheels, 1825

	Diameter		Weight of Pair		
	Ft.	In.	cwt.	qr.	lb.
1st Class: 12 pr. gun and limber, 9 & Hy. 6-pr. guns, Hy. 5 1/2 and 24-pr. howitzers — Hy. 6-pr. wheels	5		4	0	26
2nd Class: 9 and Hy. 6-pr. limber, Lt. 6-pr. gun & limber, Hy. 5 1/2-inch and 24-pr. howitzer limbers, Lt. 5 1/2-inch howitzer & limber, and 12-pr. howitzer & limber — Lt. 6-pr. wheels	5		3	2	1
3rd Class: Lt. 3-pr. and 4 2/5-inch howitzer	4	4	2	0	15
4th Class: Mountain 3-pr., 4 2/5-inch howitzer, 1-pr.	3			3	19
24-pr., 10-inch howitzer	5		8	1	10
18-pr., 8-inch howitzer	5		6	0	13
Limbers for the above	3	10	3	2	10

Adapted from RMC, Mould, pp. 168, 170.

Appendix JJ. Dimensions of Wheels, 1860s

	Weight of one			Nave		Tire	Wheel	
	cwt.	qr.	lb.	Length in.	Diameter in.	Width in.	Diameter Ft.	In.
1st or siege class								
carriages of 8-inch, 32-pr., 24 pdr., 18-pr. guns; 10-in. & 8-in. howitzers; 13-in. mortars.	4	1	5	16	18	6*	5	0
2nd or field class								
carriages of 12-pr. medium brass & 12-pdr. iron, 9 pdr. brass guns; 32-pr. & 24-pr. howitzers limbers of siege guns, howitzers, mortars; 12-pr. brass gun; 32 pr. howitzer (heavy wheel)	2	1	12	13	14	3	5	0
limbers of O.P. bracket trail siege carriages	2	0	0	13	14	4	3	10
carriages of 6-pr. guns; 12-pr. howitzer limbers of 9-pr., 6-pr. guns; 24-pr. & 12-pr. howitzers (light wheel)	1	3	23	13	14	3	5	0
limbers & carriages for 8-in. & 10-in. mortars limber of 12-pr. iron gun	1	2	26	13	14	3	4	2
3rd or general service class								
carriage & limber 3-pr. (4 feet)	1	1	0	9	12	3	4	2
Naval Service								
carriage & limber 24-pr. howitzer and 6-pr. guns	1	2	6	13 +	14	3	4	2
carriage & limber 12-pr. heavy & light howitzers & 8-inch mortar	1	0	6 3/4	11	13	3	3	6

* two 3 in. streaks
+ 2nd. class stock or nave.

Miller, Equipment of Artillery, p. 383; Owen, Elementary, p. 65; PRO, Supply Department Records, Supp. 5, 76, "Notes on Manufacturers of the Royal Carrige Department," p. 29; Lefroy, Handbook of Field Service (1867), pp. 147-48.

Appendix KK. Dimensions of Iron Work for Axletree of Travelling Carriages, 1719

	24-pdr.			12-pdr.			6-pdr.			3-pdr.			1 1/2-pdr.		
	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.
Axletree bars			1			1			1			1			1
Total length	6	6 1/4		6	5		6	5		6	3		6	2 3/4	
Breadth at centre		2 1/4			2 1/8			2			1 7/8			1 3/8	
Thickness at centre		1 1/2			1 1/3			1 1/4			1 1/8			1	
Breadth between centre & body box		2			1 7/8			1 3/4			1 5/8			1	
Breadth at body box		2 1/4			2 1/8			2			1 7/8			1 3/4	
Thickness at body box		2			1 3/4			1 1/2			1 3/8			1 1/4	
Breadth at linch pin		1 1/2			1 3/8			1 1/4			1 1/8			1	
Thickness at linch pin		1 1/2			1 3/8			1 1/4			1 1/8			1	
Axletree bolts			1			1			1			1			1
Total length		10 1/2			9 3/4			8 3/4			8			10 3/4	
Thickness		1			1			3/4			3/4			3/4	
Head's diameter		2			2			1 3/4			1 3/4			1 1/2	
Head's thickness		5/8			5/8			3/8			3/8			3/8	
Hoop in the middle of the arm			2			2			2			2			2
Breadth		2			2			2			1 3/4			1 3/4	
Thickness		1/4			1 1/4[?]			1/4			1/4			1/4	
Hoop at the linch-pin			2			2			2			2			2
Breadth		2			2			2			2			2	
Thickness		1/4			1 1/4[?]			1/4			1/4			1/4	
Washer Hurters			2			2			2			2			2
Breadth		1 1/8			1			1			7/8			7/8	
Thickness		3/4			5/8			5/8			1/2			1/2	
Strap's length		4			4			3 3/4			3 1/2			3	
Strap's breadth		3			3			2 7/8			2 3/4			2 1/4	
Strap's thickness		1/4			1/4			1/4			1/4			1/4	
Washers			2			2			2			2			2
Breadth		1 1/8			1			1			1			1	
Thickness		1/2			1/2			1/2			1/2			1/2	
Clouts at the body box			2			2			2			2			2
Length		8 1/2			7 3/4			7 1/4			6 1/4			5 1/4	
Breadth		4 3/4			4 1/2			4 1/4			4			3 3/4	
Thickness		1/16			1/16			1/16			1/16			1/16	
Clouts at the linch box			2			2			2			2			2
Length		9			8			7 1/2			7			6 1/4	
Greatest breadth		7			6 1/2			5 3/4			5 1/2			4 3/4	
Lesser breadth		5 1/2			5			4 3/4			4 1/4			3 3/4	
Thickness		1/16			1/16			1/16			1/16			1/16	
Clout Nails			40			40			40			40			40
Linch pins			2			2			2			2			2
Shank's length		8			7 1/4			6 3/4			6			5 1/4	
Shank's Breadth at shoulders		1			1			7/8			7/8			3/4	
Shank's Thickness		7/8			3/4			3/4			3/4			5/8	
Head's length		3			2 3/4			2 1/2			2 1/4			1 3/4	
Head's greatest breadth		2 1/8			1 3/4			1 3/4			1 5/8			1 1/4	
Head's Lesser breadth		1 3/4			1 1/2			1 1/4			1 1/4			1	
Crown's length		1			1			7/8			7/8			3/4	
Crown's thickness		1/2			1/2			3/8			3/8			3/8	
Single Forelockeys			1			1			1			1			2
Length		5			5			5			5			5	
Breadth		1 1/8			1 1/8			1 1/8			1 1/8			1 1/8	
Thickness		1/8			1/8			1/8			1/8			1/8	

RAI, Borgard, Tables, op. cit., No. 38, "Dimentions, Weight and Value of Iron Work for Hind and Fore Extrees for Travelling Carriages; according to the New Regulation by Colonel Albert Borgard in the Year 1719."

Appendix LL. Dimensions of Iron Work for Axletree of Limbers, 1719

	24-pdr.			12-pdr.			6-pdr.			3-pdr.		
	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.
Axletree bars			1			1			1			1
Total length	6	6		6	5 1/4		6	5 1/4		6	5 1/4	
Breadth at centre		2			1 7/8			1 5/8			1 5/8	
Thickness at centre		1 1/4			1 1/8			1			7/8	
Breadth between centre & body box		1 3/4			1 5/8			1 1/2			1 3/8	
Breadth at body box		2			1 7/8			1 3/4			1 5/8	
Thickness		1 1/2			1 1/4			1 1/8			1	
Breadth at linch pin		1 1/4			1 1/8			1 1/8			7/8	
Thickness at linch pin		1 1/4			1 1/8			1 1/8			7/8	
Axletree bolts												
Total length											1 1/4[?]	
Thickness											3/16[?]	
Head's diameter												
Head's thickness												
Hoop in the middle of the arm			2			2			2			2
Breadth		1 1/2			1 1/2			1 1/4			2	
Thickness		1/4			1/4			3/16			1/4	
Hoop at the linch pin			2			2			2			2
Breadth		2			2			2			7/8	
Thickness		1/4			1/4			1/4			1/2	
Washer Hurters			2			2			2			2
Breadth		1			7/8			7/8			7/8	
Thickness		5/8			9/16			9/16			1/2	
Strap's length		3			2 1/2			1 3/4			1 3/4	
Strap's breadth		3			2 3/8			2 1/4			2 1/4	
Strap's thickness		5/8			9/16			9/16			1/2	
Washers			2			2			2			2
Breadth		1			7/8			7/8			7/8	
Thickness		3/8			3/8			3/8			3/8	
Clouts at the body box			2			2			2			2
Length		7 1/2			7 1/4			6 3/4			5 1/4	
Breadth		4 3/8			4 1/4			4			3 3/8	
Thickness		1/16			1/16			1/16			1/16	
Clouts at the linch box			2			2			2			2
Length		7 1/4			7			6 1/2			6	
Greatest breadth		5 3/4			5 1/2			5 1/4			4 3/4	
Lesser breadth		4 3/4			4 1/4			4			3 3/4	
Thickness		1/16			1/16			1/16			1/16	
Clout Nails			40			40			40			40
Linch pins			2			2			2			2
Shank's length					6 1/4			6				
Shank's Breadth at shoulders					7/8			3/4				
Shank's thickness					3/4			5/8				
Head's length					2 1/2			2				
Head's greatest breadth					1 5/8			1 1/2				
Head's lesser breadth					1 3/8			1 1/8				
Crown's length					1			7/8				
Crown's thickness					1/2			3/8				
Single Forelockeys			3			3			3			3
Length		5			5			5			5	
Breadth		1 1/8			1 1/8			1 1/8			1 1/8	
Thickness		1/8			1/8			1/8			1/8	

RAI, Borgard, Tables, op. cit., No. 38, "Dimentions, Weight and Value of Iron Work for Hind and Fore Extrees, for Travelling Carriages; according to the New Regulation by Colonel Albert Borgard in the Year 1719."

Appendix MM. Dimensions of Carriage (Hind) and Limber (Fore) Axletrees, 1722

Calibre	Hind Wheels									
	24		12		6		3		1 1/2	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Total Length			?	6 1/4	6	5	6	3 1/4	6	2 1/2
Beds Length					3	1 1/2	3	2 1/4*	3	6 1/2
Arms Length			1	9	1	7 3/4	1	6 1/2	1	4 1/4
Bed's Depth [Width?]			0	8 1/4	0	7 1/4	0	6 1/2	0	5 1/2
Arm's or Bed's thickness	0	7	0	6 1/2	0	6	0	5 1/4	0	4 1/2
Do. before at y^e Linch	0	6 1/2	0	5	0	4 1/2	0	3 3/4	0	3

Calibre	Fore Wheels							
	24		12		6		3	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Total Length	6	6 1/2	6	6	6	5 3/4	6	5 3/4
Beds Length	3	6	3	5 1/4	3	6 1/4	3	8
Arms Length	1	7 1/4	1	6 3/8	1	5 3/4	1	4 2/8
Bed's Depth [Width?]	0	7 7/8	0	7 1/8	0	6 1/8	0	5 1/2
Arm's or Bed's thickness	0	6 1/8	0	5 5/8	0	5 1/8	0	4 1/2
Do. before at y^e Linch	0	4 3/8	0	3 7/8	0	3 1/2	0	2 3/4

Note: Blank areas had become erased in the original.

*possibly 4 1/4

RAI, James, op. cit., p. 8, "Dimentions and Draughts of Hind and Fore Wheels and Extrees for Travelling Carriages. Regulated 1722."

Appendix NN. Dimensions of the Axletrees of Travelling and Field Carriages, circa 1750-80.

Calibre		Travelling					Field		
		24 in.	18 in.	12 in.	6 in.	3 in.	24 in.	12 in.	6 in.
Total length of the Axletree		81	80.5	80	78	76	68	72	76
Body	breadth	7	7.8	6.5	6	5.5	6	5.5	5
	height	9	9.8	8.5	8	7.5	8	7	6
	length	38.5	38.8	39	40	40.5	39	40	42
Arms	length	21	20.8	20.5	19	17.5	18	16	15.7
	body, diameter	7	6.8	6.5	6	5.5	6	5.5	5
	linch, diameter	5	4.8	4.5	4	3.5	4	3.5	3

Note: The dimensions of the 18-pdr. were given by Smith only.

RAI, Adye (1766), pp. 45-6, 50-1; Muller (1780), op. cit., pp. 100, 113; Smith, op. cit., pp. 52-3.

The Iron Work of an axletree for a Travelling Carriage

		No.		
The Axletree Bar		1	Washers	2
Clouts	body	2	Lynch Pins	2
	linch	2	Axletree Bolt	1
Axletree hoops	linch	2	Single Forelock Keys	2
	arms	2	Clout Nails	12
	body	2	Dog Nails	12 (8, Smith)
Hurter with Straps		2	Axletree hoops	2

RAI, Adye (1766), pp. 48-9; Muller (1780), op. cit., pp. 109-10; Smith, op. cit., p. 53.

Appendix OO. Dimensions of the Axletrees of the Limbers for Travelling and Field Carriages, circa 1750-80.

Calibre	Travelling				Field		
	24 in.	12 in.	6 in.	3 in.	24 in.	12 in.	6 in.
Length, total	78	76	74	69	74	69	69
Body							
length	40	40	40	43	40	43	43
height	7.6	7	6.5*	5.5	6	5.5	5.5
breadth	6	5.5	5	5	5	5	4.5
Arms							
length	19	18	17	13	17	13	13
diameter, body	5	4	4	4	4	4	4
diameter, linch	4	3	3	3	3	3	3

*6 in Muller and Smith

RAI, Adye (1766), pp. 53-4, 56-7; Muller (1780), op. cit., p. 116; Smith, op. cit., p. 54. Only Adye gave the dimensions of the field limbers.

Appendix PP. Dimensions of the Galloper Carriage, circa 1750-80

	Feet	Inches
Total length of the shafts	11	0
From the fore End to ye fore cross Bar	6	4
From the hind End to the round part	5	0
Height at ye hind End	0	6
------ at the fore End	0	3
Breadth behind & before	0	3.5
----- in the middle	0	4.5
Width		
within behind	2	6.5
at the forecross bar	2	4
at the fore end	2	1
From the hind End to the Axletree	0	11
Cross Bar from the hind End	0	3
Length of the Cheeks	4	2
Breadth of Do.	0	2.5
Height of the cheeks	0	6.5
Width within		
before		8
behind		11.5
Total length of the Axletree	6	4
Body		
length	3	6.5
breadth	0	5
height	0	6
Arms		
length	1	4.6
greatest diameter	0	5
least diameter	0	3.3
Diameter of the Wheels	4	3
Nave, length	1	1
Diameter		
body	0	11
middle	1	0
linch	0	10
Spokes		
breadth	0	1.5
thickness	0	3
Fellows		
breadth	0	3
thickness	0	4.5

Adye (1766), p. 57; Muller Treatise of Artillery (1780), pp. 115-16; Smith, An Universal Military Dictionary, p. 54.

Appendix QQ. Dimensions of Axletrees for Travelling Carriages and Limbers, 1825

		Length of Axletree		Length of Bed		Length of Arm to Washer		Diamr. of Body		Diamr. of Linch	
		Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Carriage											
Iron Ordnance	24 Pr. or 10 Inch Howitzer	6	7 1/4	3	1 1/2	1	6		3 3/4		2 3/4
	24 Pr. of 6 Ft., 18 Pr., 12 Pr. of 8 Feet and 8 Inch Howitzer	6	4 3/4	3	3	1	4		3 1/2		2 1/2
Brass Ordnance	24 Pr. Howitzer, 12 Pr. of 6 Feet, 9 Pr. 12 Pr. Medium, Light 9 Pr., Hy. 6 Pr. Hy. 5 1/2 Inch Howr. & 24 Pr. Howr.	6	5	3	7	1	2		3 1/8		2 1/16
	Lt. 5 1/2 Inch Howr., 12 Pr. Howr., Lt. 6 Pr. & Hy. 3 Pr.	6	3	3	8	1	1		2 3/4		1 3/4
	Lt. 3 Pr., & 4 2/5 Inch Howitzer	4	8	2	6 1/2		11		2		1 1/2
	3 Pr., 1 Pr. ? & 4 2/5 In. Howitzer Bed	3	1 1/2	1	4 1/4		9		1 1/2		1 1/8
Limber											
Iron Ordnance	24 Pr. of 9 1/2 Feet or 6 1/2 Feet, 18 Pr. & 12 Pr. of 8 feet 10 or 8 Inch Howitzer	6	2 1/2	3	4 1/4	1	2		3 1/8		2 1/16
	24 Pr. Howitzer, 12 Pr. of 6 Feet & 9 Pr.	The same as Lt. 6 Pr. Carriages									
Brass Ordnance	24 & 12 Pr. Howr., Lt. & Hy. 5 1/2 Inch Howr. Lt. 9 Pr., Lt. 6 Pr., & Heavy 3 Pr.										
	12 Pr. medium	The same as Hy. 6 Pr. Carriages.									
	Lt. 3 Pr., 4 2/5 Inch Howr. & 1 Pounder	The same as the Carriage.									

RMC, Mould, op. cit., p. 175.

Appendix RR. Dimensions of Axletrees for Travelling Carriages, 1828

		Length of bed		Arms						Total Length		Weight incl.		
				Length of		Thickness of	Width of	Diameter						
		between shoulders		Box	Arm	Washer	Linch Hole	Shoulder	Linch	Point to Point		Linchpins, washers		
		Ft.	In.	in.	in.	in.	in.	in.	in.	Ft.	In.	cwt.	qr.	lb.
	Carriage													
Iron Ordnance	24-Pr. Gun or 10-Inch How.	3	1.5	18	20.503	.625	.875	3.75	2.75	6	6.5	1	3	8
	8-Inch Howitzer, or 18- and 12-Pounder Iron Guns	3	3	16	18.503	.625	.875	3.5	2.5	6	4	1	1	18
Brass Ordnance	Medium 12-Pr., Lt. 12-Pr., 9-Pr., Heavy 6-Pr. 24-Pr. & 5-1/2-Inch Howitzers	3	7	14	15.875	1.0	.75	3.13	2.13	6	4.5	1	-	2
	Light 6-Pr., Heavy 3-Pr., 12-Pr. Howitzer	3	8	13	15.625	1.0	.625	2.75	1.75	6	3.25	-	3	12
	6-Pr. Mountain	2	8	13	14.625	1.0	.625	2.75	1.75	5	3.25		2	22
	Lt. 3-Pr., 4 2/5-Inch Howitzer	2	6.5	11	12.75	.5	.5	2.0	1.5	4	8		1	8
	Mountain-3-Pr., 1-Pr., 4 2/5-Inch Howitzer	1	4.25	9	10.5	.375	.375	1.5	1.125	3	1.25			20
	Limber													
Iron Ordnance	24-Pr. Gun, 10-Inch How., 8-Inch How., 18-Pr. & 12-Pr. Iron Guns	3	4	14	16.503	1.0	.75	3.13	2.13	6	1.5	1	-	2
Brass Ordnance	Medium 12-Pr.	Same as for gun.												
	Light 6-Pr.	Same as for gun.												
	Mountain 6-Pr.	Same as for gun.												
	3-Pr. & 4 2/5-In. Howitzer	Same as for gun & howitzer.												

Spearman (1828), op. cit., pp. 50-1.* It is not clear, but presumably the axletree dimensions for the limbers of the other brass ordnance is the same as that of the carriage axletrees.

Appendix SS. Dimensions of Axletrees for Travelling Carriages, 1844

		Length of bed		Arms				Total Length		Weight incl.		
				Length of		Diameter						
		between shoulders Ft.	In.	Box in.	Arm in.	Shoulder in.	Linch in.	Point to Point Ft.	In.	Linchpins, washers cwt.	qr.	lb.
	Carriage											
Iron	24-Pr., 10-In. Howitzer	3	1.5	20.004	20.508	3.756	2.748	6	6.504	1	3	8.064
	18-Pr., 12-Pr.	3	3	16.008	18.504	3.504	2.508	6	4.008	1	1	18.032
Ordnance	8-Inch Howitzer	3	4.008	14.004	16.5	3.132	2.136	6	1.5	1	-	2.016
Brass	12-Pr., 9-Pr., Heavy 6-Pr., 24-Pr. Howitzer	3	7.008	14.004	15.876	3.132	2.136	6	4.5	1	-	2.016
	Light 6-Pr., Heavy 3-Pr., 12-Pr. Howitzer	3	8.004	13.008	15.624	2.748	1.752	6	3.252		3	2.016
Ordnance	Light 3-Pr., 4 2/5-Inch Howitzer	2	6.504	11.004	12.756	2.004	1.5	4	8.004		1	8.064
	Limber											
Iron	24-Pr., 18-Pr., 12-Pr., 8 In. & 10 In. Howitzers	Same as 8-Inch Howitzer										
Brass	12-Pr., 9-Pr., Heavy 6-Pr., 24-Pr. Howitzer	Same as for guns and howitzer										
	Light 6-Pr., Heavy 3-Pr., 12-Pr. Howitzer	Same as for guns and howitzer										
Ordnance	Light 3-Pr., 4 2/5-Inch Howitzer	Same as for guns and howitzer										

Spearman (1844), op. cit., "Axletree," unpaginated.

Appendix TT. Dimensions of Axletrees, 1860s

	Distance between shoulders		Arm			Weight			
			Length	Diameter					
				Shoulder	Linch				
	Ft.	In.	in.	in.	in.	Cwt.	qr.	lb.	
First or Siege Class									
8-inch of 52 cwt., 32-pr., 24 pr., 18 pr. guns; 10-inch, 8-inch howitzers; 13-inch mortar	3	4 1/2	16 5/8	3 3/4	2 7/8	1	3	9	
Second or Field Class									
Limbers of siege carriages									
Carriages & limbers of 12-pr., 9-pr. guns & 24- & 32-pr. howitzers	3	8	14	3 1/8	2 1/8	1	0	17	Heavy Axletree
Limbers of bracket trail siege carriages	3	9				1	0	22	
Carriages & Limbers of 6-pr. gun, 12-pr. howitzer	3	8				0	3	16	Light Axletree
Carriages of 10-inch & 8-inch mortars	2	9 1/2*				0	3	20	
Third or General Service Class									
Carriage & Limber of 3-pr. (of 4 feet)	2	9 1/2	9 3/8	2 1/8	1 5/8	0	1	15	
Naval Service									
Carriages & Limbers 24-pdr. how., 6-pdr. gun	2	8	11 1/2	2 3/4	1 7/8	0	3	2	
Carriages & Limbers 12-pdr. heavy & light howitzers, 8-in. mortar	2	5				0	2	15	

* Lefroy and PRO give 3 ft.

Adapted from Miller, op. cit., p. 384; Lefroy (1867), pp. 148-9; PRO, Supply Department Records, Supp. 5, 76, "Notes on the Manufactures of the Royal Carriage Department," op. cit., p. 28.

Appendix UU. Dimensions of Iron Work for Bodies of Travelling Carriages, 1719

	24-pdr.			12-pdr.			6-pdr.			3-pdr.			1 1/2-pdr.		
	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.
Plates															
Fore with hook			2			2			2			2			2
Total length		8			8			7 1/4			7 1/4			2 1/2	
Greatest breadth		3 3/4			3 3/4			2 3/4			2 3/4			2 1/2	
Lesser breadth		2 3/4			2 3/4			2 1/4			2 1/4			2 1/2	
Thickness		1/2			1/2			3/8			3/8			1/4	
Hook's total length to return		4 1/2			4 1/2			3 1/2			3 1/2				
Return's total length		2			2			2			2				
Hook's greatest diameter		1 1/4			1			7/8			7/8				
Hook's lesser diameter		5/8			1/2			1/2			1/2				
Nob's diameter		1 1/4			7/8			3/4			3/4				
Rivet hole's centre from behind		2 1/2			2 1/2			2			2				
Diameter of rivet hole		1 1/4			1 1/4			1 1/8			1 1/8			1	
Middle with hook			2			2			2			2			2
Total length	1	1/2			11			9 1/2			8 1/2			2 1/2	
Greatest Breadth		3 3/4			3 3/4			2 1/2			2 1/2			2 1/2	
Lesser Breadth		2 3/4			2 3/4			2 1/2			2 1/2			2 1/2	
Thickness		1/2			1/2			3/8			3/8			1/4	
Hook's total length to return		4 1/2			4 1/2			3 1/2							
Return's total length		2 3/8			2			2							
Hook's greatest diameter		1 1/4			1			7/8							
Hook's lesser diameter		5/8			1/2			1/2							
Nob's diameter		1 1/4			7/8			3/4							
Rivet hole's centre from each end		2			1 5/8			1 3/8			1 3/8				
Diameter of rivet hole		1 1/4			1 1/4			1 1/8			1 1/8				
Trial or hind with hook			2			2			2			2			
Total length	1	8 1/2		1	5		1	1 1/2			11 1/2				
Greatest breadth		3 3/4			3 3/4			3			2 3/4				
Lesser breadth		2 3/4			2 3/4			2 1/2			2 1/4				
Thickness		1/2			1/2			3/8			3/8				
Hook's total length to return		4 1/2			4 1/2			3 1/2			3 1/2				
Return's total length		2			2			2			2				
Hook's greatest diameter		1 1/4			1			7/8			7/8				
Hook's lesser diameter		5/8			1/2			1/2			1/2				
Nob's diameter		1 1/4			7/8			3/4			3/4				
Rivet hole's centre from behind		2 1/8			2 1/8			1 3/4			1 3/4				
Rivet hole's centre from before		6			5 3/4			4 1/4			3 3/4				
Diameter of rivet hole		1 1/4			1 1/4			1 1/8			1 1/8				
Head or breast			2			2			2			2			
length	3	1 1/2		2	5 1/2		1	7 1/2		1	2 1/2				
breadth		5 3/4			4 1/2			3 7/10			3				
thickness		1/8			1/8			1/8			1/8				
Garnish			2			2			2			2			
length	3	6		3	3 1/2		3	3 3/4		2	5 1/4				
breadth		5 3/4			4 1/2			3 7/10			3				
thickness		1/8			1/8			1/8			1/8				
Under															
length															
breadth															
thickness															
Trail			2			2			2			2			2
length	7	5		5	10 1/2		4	11		4	5		2	1	
breadth		5 3/4			4 1/2			3 7/10			3			2 1/4	
thickness		1/8			1/8			1/8			1/8			1/8	
Upper Pintail with strap			1			1			1			1			
total length with strap	1	3 1/4		1	2			11 1/2			10				
strap's breadth		2 1/4			2 1/4			2			2				
thickness		5/16			5/16			1/4			1/4				
Oval's greatest diameter		10 1/2			10			9			8				
D°. clear		7 1/2			7			6			5 1/4				
Oval's lesser diameter		8 3/4			7 1/2			7			6 1/2				
D°. clear		5 5/8			4 3/4			4 1/2			4				
Shank hole's centre from strap end		1 1/4			1 1/4			1 1/8			1 1/8				
Diameter of shank hole		3/4			3/4			5/8			5/8				

Appendix UU. Dimensions of Iron Work for Bodies of Travelling Carriages, 1719, cont.

	24-pdr.			12-pdr.			6-pdr.			3-pdr.			1 1/2-pdr.		
	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.
Under Pintail with strap			1			1			1			1			
total length with strap	1	8 3/4		1	5 1/2		1	1			11				
strap's length forward from the clear of the hole		9			8			6 1/4			5 1/4				
D°. hind		5 1/4			3 1/2			3			2 1/4				
Return's length		2 3/4			2 1/2			1			3/4				
Strap's breadth		2 1/4			2 1/4			2			2				
Thickness		5/16			5/16			1/4			1/4				
Oval's greatest diameter		6 5/8			6 1/4			5 3/4			5 1/2				
D°. clear		3 3/4			3 1/2			3			2 3/4				
Oval's lesser diameter		5 5/8			5 3/8			5 1/4			4 3/4				
D°. clear		2 8/10			2 7/10			2 3/8			2 1/4				
Plate's thickness at the hole's edge		5/8			5/8			5/8			5/8				
Plate's thickness at the out edge		1/4			1/4			1/4			1/4				
Trunnion			2			2			2			2			2
Total length	2	7 1/2		2	5 1/2		2	1 3/4		2			4	1/2	
Length behind trunnion	1	6 3/4		1	6		1	4		1	3		2	8	
Length before trunnion		7			7			6			6			5 1/4	
Breadth		5 7/10			4 4/10			3 1/2			2 7/8			2 1/4	
Thickness at the end		3/16			3/16			3/16			3/16			3/16	
at the trunnion		5/8			1/2			3/8			5/16			3/16	
behind the trunnion		7/8			3/4			5/8			1/2			3/16	
Fore eye-bolt's centre from trunnion		3 3/4			3 7/12			3 1/2			3 1/2			1 3/8	
Hind eye-bolt's centre from trunnion		1 4/10			1 1/8			7/8			7/8				
Joynt bolt's centre from trunnion		9			8 3/10			7 1/2			6 1/4			2 1/4	
Garnish bolt's centre from trunnion	1	4 3/4		1	3 5/8		1	2 1/4		1	3/4				
Diameter of eye and joynt bolt's hole		1			1			7/8			13/16			3/4	
Diameter of the Garnish		1			1			7/8			13/16				
Locking			2			2			2			2			
length		7			7			6			6				
breadth		3			3			2 3/4			2 3/4				
thickness		3/16			3/16			3/16			3/16				
Side strap or garter			4			4			4			4			
Fore															
total length	3	8 7/10		3	6/10		2	5		2	3/8				
breadth		2			1 3/4			1 1/2			1 1/2				
thickness		3/16			3/16			3/16			3/16				
Hind															
total length	3	2 7/10		2	6 6/10		2	1		1	7 1/2				
breadth		2			1 3/4			1 1/2			1 1/2				
thickness		3/16			3/16			3/16			3/16				
Bolts															
Fore riveting			1			1			1			1			1
total length	2	6		2	2 1/2		1	9		1	5 3/4		1	3/8	
thickness		1 1/4			1 1/4			1 1/8			1 1/8			1	
head and burr's diameter		2 1/2			2 1/2			1 3/4			1 3/4			1 1/2	
Middle			2			2			2			2			2
total length	2	10		2	5		2			1	8 1/4		1	1 7/8	
thickness		1 1/4			1 1/4			1 1/8			1 1/8			1	
head and burr's diameter		2 1/2			2 1/2			1 3/4			1 3/4			1 1/2	
Trail			2			2			2			2			
total length	3	2 3/4		2	8 1/2		2	3		1	11 1/2				
thickness		1 1/4			1 1/4			1 1/8			1 1/8				
head and burr's diameter		2 1/2			2 1/2			1 3/4			1 3/4				
Eye			4			4			4			4			2
total length	2	1/4		1	9 1/4		1	6		1	3 1/4		1	1/2	
thickness		1			1			7/8			13/16			3/4	
head's length		2 1/4			2 1/8			2			2			1 1/2	
head's breadth		2			1 7/8			1 3/4			1 3/4			1 1/2	
head's thickness		1			1			7/8			13/16			3/4	
key-hole's length		1 1/8			1 1/8			1			1			1	
key-hole's beadth		3/16			3/16			3/16			3/16			3/16	
Joynt			2			2			2			2			2
total length	2	1/4		1	9 1/4		1	6		1	3 1/4		1	1/2	
thickness		1			1			7/8			13/16			3/4	
joynt's greatest diameter		1 7/8			1 3/4			1 1/2			1 1/2			1 1/8	
joynt's lesser diameter		7/8			3/4			5/8			5/8			1/2	
joynt's thickness		1/2			1/2			7/16			7/16			5/16	
key-hole's length		1 1/8			1 1/8			1			1			1	
key-hole's breadth		3/16			3/16			3/16			3/16			3/16	

Appendix UU. Dimensions of Iron Work for Bodies of Travelling Carriages, 1719, cont.

	24-pdr.			12-pdr.			6-pdr.			3-pdr.			1 1/2-pdr.		
	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.
Rivet for joynt			2			2			2			2			2
length		6			4 7/10			3 3/4			3 1/8			2 1/2	
thickness		7/8			3/4			5/8			5/8			1/2	
Garnish			2			2			2			2			
total length	1	11 1/4		1	8		1	5		1	2 1/2				
thickness		1			1			7/8			13/16				
head's length		2 3/8			2 1/8			1 7/8			1 3/4				
head's thickness		2			1 7/8			1 3/4			1 7/16				
groove's centre from shoulder		5/8			1/2			3/8			3/8				
groove's breadth		1/2			4/10			3/10			3/10				
groove's depth		2/10			2/10			1/8			1/8				
Ear Bread															2
total length														6	
thickness														3/4	
head's diameter														1 1/8	
Ring with bolt for draught chains			2			2			2						
total length		5			4			3 1/2							
thickness		3/4			3/4			5/8							
head's greatest diameter		2 1/2			2 1/2			2 1/8							
head's lesser diameter		1			1			7/8							
head's thickness		3/4			3/4			5/8							
ring's greatest diameter		5 1/4			5			4 3/8							
ring's thickness		3/4			3/4			5/8							
Pintail plate ring complete			1			1			1			1			
diameter of ring in the clear		3 1/2			3 1/2			3			3				
thickness of ring		3/4			3/4			5/8			5/8				
shank's length		6			4 3/4			4 1/4			3 1/2				
shank's thickness		3/4			3/4			5/8			5/8				
breadth of shank's head		2			2			1 3/4			1 3/4				
thickness of shank's head		5/8			5/8			1/2			1/2				
Lashing ring complete			8			8			8			8			
total length		4			4			3			3				
thickness		3/8			3/8			3/8			3/8				
head's greatest diameter		1 1/4			1 1/4			1 1/4			1 1/4				
head's lesser diameter		1/2			1/2			1/2			1/2				
head's thickness		3/8			3/8			3/8			3/8				
ring's greatest diameter		2 1/4			2 1/4			2			2				
ring's thickness		3/8			3/8			3/8			3/8				
Capsquare with joynt			2			2			2			2			2
length when turned	1	11 1/2		1	9		1	7		1	4 3/4			8 5/8	
breadth		5 7/10			4 4/10			3 1/2			2 7/8			2 1/4	
thickness		9/16			1/2			3/8			3/8			1/4	
joynt's greatest diameter		1 7/8			1 3/4			1 1/2			1 1/2			1 1/8	
joynt's lesser diameter		7/8			3/4			5/8			5/8			1/2	
eye-bolt hole's length		2 1/4			2 1/8			2			2			1 3/4	
eye-bolt hole's breadth		1 1/8			1 1/8			1			15/16			7/8	
Axletree bands			2			2			2			2			
total length when turned	2	11 1/2		2	5 1/2		2	3 1/2		2	1/4				
bracket's length on each side X-tree	1	2 1/4			11 1/2			10 3/4			9 1/2				
breadth		5 1/4			4 1/4			3 1/4			2 3/4				
thickness		5/8			9/16			1/2			3/8				
First centre-hole from axletree		2 1/4			2 1/8			1 7/8			1 3/4				
Second centre-hole from axletree		9 1/4			9 1/8			7 1/2			7 1/2				
Hole's diameter		1			1			7/8			13/16				
Nails															
Garnish			6			6			6			4			6
total length		7 3/8			6 5/8			5 7/8			5 3/4			5	
thickness		3/4			3/4			5/8			5/8			1/2	
head's length		2 3/8			2 1/8			1 7/8			1 3/4			1 1/2	
head's thickness		2			1 7/8			1 3/4			1 7/16			1 1/4	
groove's centre from shoulder		5/8			1/2			3/8			3/8			3/8	
groove's breadth		1/2			4/10			3/10			3/10			3/10	
groove's depth		2/10			2/10			1/8			1/8			1/8	

Appendix UU. Dimensions of Iron Work for Bodies of Travelling Carriages, 1719, cont.

	24-pdr.			12-pdr.			6-pdr.			3-pdr.			1 1/2-pdr.		
	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.
Square-headed plate			91			87			87			69			8
head's square		1/2			1/2			1/2			1/2			1/2	
head's thickness		5/16			5/16			1/4			1/4			1/4	
shank's length		3			3			2 1/2			2 1/2			2 1/2	
shank's thickness		1/4			1/4			3/16			3/16			3/16	
Rose for trail and garnish plate			4			4			4			4			2
shank's length		5 1/2			5 1/2			4			4			4	
shank's thickness		3/4			3/4			1/2			1/2			1/2	
head's length		1 1/8			1 1/8			3/4			3/4			3/4	
head's diameter		1			1			5/8			5/8			5/8	
Dog			33			33			27			27			27
length		3 1/4			3			3			2 1/2			2 1/2	
thickness		1/4			1/4			1/4			1/4			1/4	
Locker hinge						14			14			14			28
length					1 7/8			1 7/8			1 7/8			1 7/8	
thickness					3/16			3/16			3/16			3/16	
head's diameter					5/16			5/16			5/16			5/16	
Locker Hinges						2			2			2			4
total length					8 3/8			8 3/8			8 3/8			8 3/8	
cross part-length					3 5/8			3 5/8			3 5/8			3 5/8	
breadth					7/8			7/8			7/8			7/8	
thickness					1/8			1/8			1/8			1/8	
tail part-length					7			7			7			7	
greatest breadth					1 1/2			1 1/2			1 1/2			1 1/2	
lesser breadth					3/8			3/8			3/8			3/8	
length from cross part to joynt's centre					1 3/8			1 3/8			1 3/8			1 3/8	
joynt's greatest diameter					3/8			3/8			3/8			3/8	
rivet's diameter					1/8			1/8			1/8			1/8	
the hinge's tail part's diameter					1			1			1			1	

RAI, Borgard, Tables, No. 39-41, "Dimentions, Weight, and Value of Iron Work for Bodies of Travelling Carriages according to the New Regulation in 1719."

Appendix VV. Dimensions of the Bodies of Travelling Carriages according to the New Regulation 1719

Calibre	24		12		6		3		1 1/2	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Sides										
Total length	13	0	11	10 1/2	11	5 1/2	9	4		
Total Breadth	1	9 3/4	1	6 4/10	1	2 8/10	0	11 7/10		
Depth at ye face of the Carriage	1	8 4/10	1	5 1/4	1	1 6/10	0	10 7/10		
Center of the Tronions from ye face of ye Carriage	1	5 1/10	1	1 6/10	0	10 8/10	0	8		
Length from Do. to ye Back brake	5	0 3/4	4	6 1/4	4	4 3/4	3	4 1/4		
Depth at ye Back Brake or Middle Camber	1	5 1/2	1	2 3/4	1	0	0	9 1/2		
Len: from ye. B. brake to ye Rebate mouldings foot	0	10	1	6 3/4	1	4 1/8	1	1 1/4		
Length from ye. Camber to ye. Locking Circle	1	6 1/2	2	0 7/8	1	9	1	7		
Reverse Circles length from ye. end of ye. plank	1	5 4/10	1	1 8/10	0	11 1/10	0	9 4/10		
Depth of ye. Reverse Circle brake	1	1	0	11 1/2	0	9 1/8	0	7 1/8		
Trains or Reverse Circles Brakes length	1	6	1	3	1	0	0	10 1/4		
Len. from ye. Rev.Circ.Bra. to ye. Reb. moulds foot	0	6 9/10	0	5 6/10	0	4 7/10	0	3 5/8		
Total Depth at the Reverse Circle	1	2 5/8	1	0 9/10	0	10 5/8	0	8 1/2		
Locking Circle's Semidiameter	0	1 3/4	0	1 1/2	0	1 1/4	0	1 1/8		
Total Thickness	0	5 8/10	0	4 6/10	0	3 7/10	0	3		
Thickness of ye. Rebate part	0	4 7/10	0	3 6/10	0	3	0	2 3/8		
Fore Transoms										
Total length	1	6 1/4	1	1	1	0 3/8	0	10 3/4		
Do. in the clear next the Tronion	1	4 1/4	1	0 5/8	0	9 3/4	0	8 3/4		
Total Breadth	0	11	0	10 1/2	0	7	0	6		
Facing both ways length	0	1 1/2	0	1 1/2	0	1 1/2	0	1 1/2		
Transoms place from ye. back of ye. Cheeks	0	5 3/4	0	4 3/8	0	3 1/2	0	2 1/2		
Circles depth from ye. upside of ye. Transom	0	3 1/2	0	2 1/2	0	2 1/4	0	2 1/4		
Transoms Thickness	0	5 8/10	0	4 6/10	0	3 7/10	0	3		
Middle Transoms										
Total length	1	9 1/4	1	6 1/4	1	2 3/8	1	0 3/4		
Do. in ye clear next ye Back Brake	1	7 1/4	1	4 1/4	1	0				
Total breadth	1	1 1/2	0	11 1/2	0	9	0	7 1/4		
Facing from ye. upside length	0	3	0	2 3/10	0	1 1/2	0	1 1/2		
Do. from the under side	0	2	0	2	0	1 1/2	0	1 1/2		
Transoms place from ye Back brake	0	1 1/2	0	1 1/2	0	1	0	1		
Transoms Thickness										
Bridge Transoms										
Total length	1	8 1/2	1	5	1	2	1	0		
Do Breadth	0	8 3/4	0	7	0	7	0	5 1/4		
Facing each way	0	1 1/2	0	1 1/2	0	1	0	1		
Transoms place from ye. clear of ye. Transom	1	0 3/4	0	11 5/8	0	10	0	5 5/8		
Transoms Thickness	0	5 8/10	0	4 6/10	0	3 7/10	0	3		

Appendix VV. Dimensions of the Bodies of Travelling Carriages according to the New Regulation 1719

Calibre	24		12		6		3		1 1/2	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Trail Transoms										
Total length	2	1 1/4	1	11	1	7	1	5		
Do in ye. clear of ye. end	1	11 1/4	1	9	1	4 3/4	1	2 3/4		
Total breadth	1	6	1	3	1	0	0	10 1/4		
Facing each way	0	2	0	2	0	1 1/2	0	1 1/2		
Transoms place from ye. Reverse brake	0	4 1/2	0	4	0	3	0	2 3/4		
Transoms Thickness	0	5 8/10	0	4 6/10	0	3 7/10	0	3		
Bedd Piece										
Total Length	1	6 1/2	1	4 3/10	1	1 1/2	0	8 5/8		
Do Breadth	0	11	0	10	0	8 1/2	0	7 1/2		
Facing each way	0	0 1/2	0	0 1/2	0	0 1/4	0	0 1/4		
Thickness	0	3 9/10	0	3 3/10	0	2 7/8	0	2 1/2		
Lockers										
Width in ye. clear			1	1 1/2	0	11	0	9		
Total depth of ye. fore part			1	0 1/8	0	9 3/4	0	7 1/2		
Do. in ye. clear			0	9 1/8	0	6 3/4	0	4 3/8		
Total length of ye. fore part			1	7 1/8	1	3 1/4	1	1 1/4		
Do. in ye. clear			1	5 1/8	1	1 3/4	0	11 1/4		
Fillets for ye. bottom of ye. Locker length			1	7	1	3 1/2	1	1		
Do. greatest breadth			0	2	0	2	0	2		
Do. lesser breadth & thickness			0	1	0	1	0	1		
Do. Thickness of the hanging Fillet			0	1 1/2	0	1 1/2	0	1 1/2		
Bottom Coin										
Total Length	1	9	1	9	1	6	1	3	1	3
Do. breadth	0	11	0	11	0	10	0	8	0	8
Greatest thickness	0	6	0	6	0	4 1/2	0	4	0	3 3/4
Do. Lesser	0	3	0	3	0	2 1/4	0	2	0	1 7/8
Top Coin										
Total Length	1	6	1	6	1	3	1	0	1	0
Do. breadth	0	10	0	10	0	9	0	7	0	7
Greatest Thickness	0	5	0	5	0	3 1/2	0	3	0	2 3/4
Do. Lesser	0	1 1/2	0	1 1/2	0	1 1/4	0	1	0	0 7/8
holes distance from ye. end in ye. clear										
Do.s breadth										
Do.s depth at ye. square part										

RAI, James, op. cit., p. 2.

Appendix WW. Dimensions of the Brackets of Travelling and Field Carriages, 1750-80

Calibre	Travelling					Field		
	24 in.	18 in.	12 in.	6 in.	3 in.	24 in.	12 in.	6 in.
Length of the bracket	156	150	144	132	120	108	106	94
Thickness	5.8	5.2	4.6	3.6	3	4.5	3.7	3
Height of the plank	22	21.6	19	16	13	15.6	14	12.4
Height of the bracket								
before	20	19.6	17	14	11.5	14.5	12.7	11
centre	17	16.6	15	12*	9.5	12	10.9	9.8
trail	12	11.6	11	10	7.5	10	9.2	8.4+
Dist. of the head from the centre	74	72	69	60	51.5	50	45	40
Length of the trail	18	16.6	15	12	10	11	10.5	10
Width								
before						11.5	10.7	10
behind						17	15	13

* 10 and +8 in Smith.

RAI, Adye (1766), pp. 45-6, 50-1; Muller (1780), op. cit., pp. 100, 112; Smith, pp. 52-3. Only Smith gives the dimensions for the brackets of the 18-pdr.

The Iron Work of the Travelling Carriage

	No.
Transom bolts with burrs	
breast	1
centre	2
trail	2
Transom plates with hooks	
breast	2
centre	2
trail	2
Trunnion plates	2
Cap squares with joint bolts	2
Spring keys, chains & staples	4
Eye bolts	
fore	2
hind	2
Breast plates	2
Plates with roses	
garnish	2
trail	2
Garnish bolts	2
Garnish nails	6

	No.
Axletree bands	2
Side straps	4
Draught rings, bolts & burrs	2
Locking plates	2
Lashing rings with loops	8
Single forelock keys	8
Bed piece chain with staple	1
Locker hinges	2
Locker hasp and staples	1
Pintle plates, upper and under	2
Rivets	
Nails	
rosebud	4
diamond headed	8
countersunk	
trail	26
Wood screws	

RAI, Adye (1766), pp. 46-7; Muller (1780), op. cit., pp. 106-7; Smith, op. cit., pp. 52-3. The nails were given by Smith and the wood screws and rivets by Muller and Smith, but no quantities of the latter.

Appendix XX. Construction of Travelling Carriages According to John Muller, 1750–80

Let Abcd be the plank, and AB the height before of the cheeks; set off from B to C the sum of the head AB, and the distance from the hind part of the trunnions to the extremity of the cascable; then from the point A as center, describe an arc CD through the point C, on which as a chord set off the height at the centre, and draw the lines AD, BC. On BC take BE, equal to the head AB, and towards the head Er, rS, each equal to half the diameter of the trunnions, so that ES will be the width of the trunnion hole, whose centre is about a quarter of an inch below the line BC. From the point r draw rF, perpendicular to AD; in AD take FH, equal to the breadth of the axle-tree, which is sunk about an inch into the cheeks. On the side FH make a square, and from the intersection I of diagonals, as center, describe an arc, with a radius of 29 inches, or equal to the radius of the wheel; this arc will represent a part of the wheel. Then if a ruler be laid so as to touch this arc, and cut the plank in two points ML, such that the distance ML be equal to the length of the trail, and you erect at these points two perpendiculars MN, LO, to KM, each equal to the height of the trail; by drawing the lines CN, NO, and DM, you will have the figure ABCNOLDA of the cheek required.

The part MP is made round, that the carriage may slide with more ease on the ground, which is done by dividing LO into four equal parts, so that LP be one of them, by drawing MP; and at the points M and P, erecting two perpendiculars on DM, and on MP, which meeting in Q, then the point R, which bisects MQ, will be the center of the arc MP required.

The mortise V of the center transom is determined by drawing a line through the point C, perpendicular to the horizon KM, in which Cp is taken equal to a fourth part of the shot's diameter, and pq equal to two of these diameters for the height, and in pz, parallel to KM, the breadth px equal to one diameter. The distance between the center and bed transom X is two diameters; this last is a diameter each way. The breast transom Y is a diameter broad and two high; the sides are parallel to the head AB, and terminate above even with the bottom of the trunnion hole one way, and when produced the inside meets the point S. Lastly, the mortise T of the trail transom is equal in length to the trail, a diameter high, and is parallel to the upper side NO, so as when the lower is produced to meet the point P.

All these mortises are divided into four equal parts by horizontal lines; the upper part is sunk half an inch into the cheeks; the two middle parts are sunk to the depth of two thirds of the thickness of the cheeks, but the lower part is not sunk in at all. They are made in this manner to prevent the wet from getting into the joint and rotting the tenons.

Construction of the plan

Draw the indefinite line AB, in which take the points CD, so as their interval be equal to the distance from the center of the trunnions to the extremity of the base ring; through these points draw EF, KL, at right angles, to AB; make DK, DL, each equal to the radius of the base ring, and CE, CF, each equal to the radius of the second reinforce ring; then the lines drawn through the points F, L, and E, K, will determine the width within of the carriage; if to these lines two others are drawn parallel, and at a distance equal to the length of the trunnions, you will have the thickness of the cheeks QP and RS.

On both sides of the points E and F, set off half the diameter of the trunnions, in order to have the trunnion holes m, n; draw the breast transom Y of a diameter broad, so as the inside be in a line with the fore part of the trunnion holes; and if CA be taken equal to rB in the last figure, the line RQ at right angles to AB will determine the breast of the carriage, and the total length AB of the carriage is determined by the last figure.

If you set off from the line KL two diameters for the length of the cascable, you will have the hind part of the center transom V, whose width is a diameter as well as the bed transom X, and their interval is two of these diameters, as has been said before; the trail transom T is determined as before by the length of the trail. In the middle of this transom is the pintle hole of an oval figure, wider above than below, that the pintle may have room to play on uneven ground.

The bed w is a board of an inch and a half thick, a foot broad, and sunk into the bed and center transoms; the width of the axle-tree has been determined before, and its fore part passes through the centers of the trunnion holes: there is a board fixed upon the axle-tree with one end, and the other upon the bed transom, which serves to lay hay or straw upon for wadding.

Between the trail and center the breadth of the cheeks is diminished on the inside by a sixth part, beginning at about a diameter from the trail, and ends within a diameter and a half from the center transom.

This is the common construction of field carriages; but as it relates only to the four calibers, whose dimensions have been given, the reader will still be at a loss how to construct any other; and as the length of the cheeks depends not only on the caliber of the gun, but likewise on the height of the wheels, as well as on the length of the pieces, which varies very often: therefore, in the following construction, we suppose the wheels of the common size, and the guns to be 20 to 21 diameters long, which is the common length at present of the 24 pounders.

General dimensions of travelling Carriages.

The length Ad of the plank is 12 diameters of the shot and 7.5 feet besides; its height Ab three diameters and three quarters; the height AB of the cheeks three diameters and a quarter; so that Bb is half a diameter, the height DC at the center 70 parts of that diameter, divided into 24 equal parts, as in the construction of guns; the length of the trail is three diameters, and its height MN two; the breadth FH of the axle-tree is two diameters, and the rest of the dimensions depend on the size of the gun.

Source: Muller Treatise of Artillery (1780), pp. 100-4.

Appendix YY. Dimensions of the Iron Work of the Body of a Howitzer Carriage, 1719

	Ft.	In.	No.
Plates			
Fore with hook			2
Total length		8	
Greatest breadth		3 3/4	
Lesser breadth		2 3/4	
Thickness		1/2	
Hook's total length to return		4 1/2	
Return's total length		2	
Hook's greatest diameter		1	
Hook's lesser diameter		1/2	
Nob's diameter		7/8	
Rivet hole's centre from behind		2 1/2	
Diameter of rivet hole		1 1/4	
Middle with hook			2
Total length	1	1 1/2	
Greatest Breadth		3 3/4	
Lesser Breadth		2 3/4	
Thickness		1/2	
Hook's total length to return		4 1/2	
Return's total length		2	
Hook's greatest diameter		1	
Hook's lesser diameter		1/2	
Nob's diameter		7/8	
Rivet hole's centre from each end		1 5/8	
Diameter of rivet hole		1 1/4	
Trail or hind with hook			2
Total length	1	5	
Greatest breadth		3 3/4	
Lesser breadth		2 3/4	
Thickness		1/2	
Hook's total length to return		4 1/2	
Return's total length		2	
Hook's greatest diameter		1	
Hook's lesser diameter		1/2	
Nob's diameter		7/8	
Rivet hole's centre from behind		2 1/8	
Rivet hole's centre from before		5 3/4	
Diameter of rivet hole		1 1/4	
Head or breast			2
length	1	11	
breadth		4 1/2	
thickness		1/8	

Appendix YY. Dimensions of the Iron Work of the Body of a Howitzer Carriage, 1719, cont'd

	Ft.	In.	No.
Garnish			2
length	1	1	
breadth		4 1/2	
thickness		1/8	
Trail			2
length	5	10 1/2	
breadth		4 1/2	
thickness		1/8	
Upper Pintail with strap			1
total length with strap	1	2	
strap's breadth		2 1/4	
thickness		5/16	
Oval's greatest diameter		10	
D^o. clear		7	
Oval's lesser diameter		7 1/2	
D^o. clear		4 3/4	
Shank hole's centre from strap end		1 1/4	
Diameter of shank hole		3/4	
Under Pintail with strap			1
total length with strap	1	5 1/2	
strap's length forward from the clear of the hole		8	
D^o. hind		3 1/2	
Return's length		2 1/2	
Strap's breadth		2 1/4	
Thickness		5/16	
Oval's greatest diameter		6 1/4	
D^o. clear		3 1/2	
Oval's lesser diameter		5 3/8	
D^o. clear		2 7/10	
Plate's thickness at the hole's edge		5/8	
Plate's thickness at the out edge		1/4	
Trunnion			2
Total length	2	5 1/2	
Length behind trunnion	1	6	
Length before trunnion		7	
Breadth		4 4/10	
Thickness at the end		3/16	
at the trunnion		1/2	
behind the trunnion		3/4	
Fore eye-bolt's centre from trunnion		3 7/12	
Hind eye-bolt's centre from trunnion		1 1/8	
Joynt bolt's centre from trunnion		8 3/10	

Appendix YY. Dimensions of the Iron Work of the Body of a Howitzer Carriage, 1719, cont'd

	Ft.	In.	No.
Garnish bolt's centre from trunnion	1	3 3/8	
Diameter of eye and joynt bolt's hole		1	
Diameter of the Garnish		1	
Locking			2
length		7	
breadth		3	
thickness		3/16	
Side strap or garter			4
Fore			
total length			
breadth			
thickness			
Hind			
total length			
breadth			
thickness			
Bolts			
Fore riveting			2
total length	2	2 3/4	
thickness		1 1/4	
head and burr's diameter		2 1/2	
Middle			2
total length	2	4 1/4	
thickness		1 1/4	
head and burr's diameter		2 1/2	
Trail			2
total length	2	7	
thickness		1 1/4	
head and burr's diameter		2 1/2	
Eye			4
total length	1	9	
thickness		1	
head's length		2 1/8	
head's breadth		1 7/8	
head's thickness		1	
key-hole's length		1 1/8	
key-hole's breadth		3/16	
Joynt			2
total length	1	8 1/4	
thickness		1	
joynt's greatest diameter		1 3/4	
joynt's lesser diameter		3/4	

Appendix YY. Dimensions of the Iron Work of the Body of a Howitzer Carriage, 1719, cont'd

	Ft.	In.	No.
joynt's thickness		1/2	
key-hole's length		1 1/8	
key-hole's breadth		3/16	
Rivet for joynt			2
length		4 7/10	
thickness		3/4	
Garnish			2
total length	1	8	
thickness		1	
head's length		2 1/8	
head's thickness		1 7/8	
groove's centre from shoulder		1/2	
groove's breadth		4/10	
groove's depth		2/10	
Ring with bolt for draught chains			2
total length		4	
thickness		3/4	
head's greatest diameter		2 1/2	
head's lesser diamerter		1	
head's thickness		3/4	
ring's greatest diameter		5	
ring's thickness		3/4	
Pintail plate ring complete			1
diameter of ring in the clear		3 1/2	
thickness of ring		3/4	
shank's length		4 3/4	
shank's thickness		3/4	
breadth of shank's head		2	
thickness of shank's head		5/8	
Lashing ring complete			8
total length		4	
thickness		3/8	
head's greatest diameter		1 1/4	
head's lesser diameter		1/2	
head's thickness		3/8	
ring's greatest diameter		2 1/4	
ring's thickness		3/8	
Capsquare with joynt			2
length when turned	1	9	
breadth		4 4/10	
thickness		1/2	

Appendix YY. Dimensions of the Iron Work of the Body of a Howitzer Carriage, 1719, cont'd

	Ft.	In.	No.
joynt's greatest diameter		1 3/4	
joynt's lesser diameter		3/4	
eye-bolt hole's length		2 1/8	
eye-bolt hole's breadth		1 1/8	
Axletree bands			2
total length when turned	2	5 1/2	
bracket's length on each side X-tree		11 1/2	
breadth		4 1/4	
thickness		9/16	
First centre-hole from axletree		2 1/8	
Second centre-hole from axletree		9 1/8	
Hole's diameter		1	
Nails			2
Garnish			
total length		6 5/8	
thickness		3/4	
head's length		2 1/8	
head's thickness		1 7/8	
groove's centre from shoulder		1/2	
groove's breadth		4/10	
groove's depth		2/10	
Square headed plate			75
head's square		1/2	
head's thickness		5/16	
shank's length		3	
shank's thickness		1/4	
Rose for trail and garnish plate			4
shank's length		5 1/2	
shank's thickness		3/4	
head's length		1 1/8	
head's diameter		1	
Dog			33
length		3	
thickness		1/4	

RAI, Borgard, Tables, No. 39-41, "Dimentions, Weight, and Value of Iron Work for Bodies of Travelling Carriages according to the New Regulations in 1719."

Appendix ZZ. Dimensions of the Bodies of Howitzer Travelling Carriages According to the New Regulation 1719.

	Ft.	In.
Sides		
Total Length	10	0
Total Breadth	1	5
Depth at ye. face of the Carriage	1	5
Center of the Tronions from ye face of ye Carriage	1	0
Length from Do. to ye Back brake	2	6
Depth at ye. Back Brake or Middle Camber	1	5
Len: from ye. B brake to ye Rebate mouldings foot		
Length from ye. Camber to ye. Locking Circle	1	1
Reverse Circles length from ye. end of ye. plank	1	1 3/4
Depth of ye. Reverse Circle brake	0	11 1/4
Trains or Reverse Circles Brakes length	1	3
Len. from ye. Rev. Circ. Bra. to ye. Reb. mouldings foot		
Total Depth at the Reverse Circle	1	0 9/10
Locking Circle's Semidiameter	0	1 3/4
Total Thickness	0	4 1/2
Thickness of ye. Rebate part	0	4 1/2
Fore Transoms		
Total length	1	4
Do. in the clear next the Trunion	1	2 1/2
Total Breadth	0	8 3/4
Facing both ways length	0	1 1/2
Transoms place from ye. back of ye. Checks	0	8
Circles depth of ye. upside of ye. Transom	0	4
Transoms Thickness	0	4 1/2
Middle Transoms		
Total length	2	1
Do. in ye. clear next ye. Back Brake	1	3 1/2
Total breadth	1	4 3/4
Facing from ye. upside length	0	2
Do. from the under side	0	5
Transoms place from ye. Back brake	0	2 1/2
Transoms Thickness	0	4 1/3
Bridge Transoms		
Total Length		
Do Breadth		
Facing each way		
Transoms place from ye. clear of ye. Transom		
Transoms Thickness		
Trail Transoms		
Total Length	1	8
Do in ye. clear of ye. end	1	7 1/2

Appendix ZZ. Dimensions of the Bodies of Howitzer Travelling Carriages According to the New Regulation 1719, cont'd

	Ft.	In.
Total breadth	1	3
Facing each way	0	2
Transoms place from ye. Reverse brake	0	4
Transoms Thickness	0	4 1/2
Bedd		
Total Length		
Total Breadth before		
Breadth before in ye. clear		
Total breadth behind		
Breadth behind in ye. clear		
Bedds Thickness		
Bedds Center from ye. under side		
Letting in parts length		
Bedd Piece		
Total Length	2	2 1/2
Do Breadth	0	10
Facing each way		
Thickness	0	4
Lockers		
Width in ye. clear		
Total depth of ye. fore part		
Do. in ye. clear		
Total length of ye. fore part		
Do. in ye. clear		
Filletts for ye. bottom of ye. Locker length		
Do. greatest breadth		
Do. lesser breadth & thickness		
Do. Thickness of the hanging Fillet		
Bottom Coin		
Total length	1	9
Do. breadth	0	11
Greatest thickness	0	6
Do. Lesser	0	3
Top Coin		
Total Length	1	6
Do. breadth	0	10
Greatest Thickness	0	5
Do. Lesser	0	1 1/2
holes distance from ye. end in ye. clear		
Do.s breadth		
Do.s depth at ye. square part		

RAI, James, p. 2.

Appendix AAA. Dimensions of Carriage for 8-Inch Howitzer, 1750-80

	In.
Length of the Cheeks	101
Thickness of Do	4.5
Height of Do	
before	18
at the center	16
at the trail	14
Length of the trail	15
Height of the plank	18
From the head to the center	43
From the Center of ye End of ye trail	54
Breast Transom	
length	14.5
height	8.8
thickness	4.5
Center Transom	
length	16.5
height	14
thickness	4.5
Trail Transom	
length	19
height	15
thickness	4.5
Trunnion holes from the head	9
Diameter of the Trunnion holes	5
Breast Transom from the head	5
From the head to the Axletree	14.5
Length of the Axletree	75
Body	
length	35
breadth	6.5
height	8
Arms	
length	20
breadth	6
height	4.5
Breast transom) from the upper	7.5
Center transom) part of ye Cheek	3
Diameter of the Wheels	58
Nave, length	17
Diameter	
body	15
middle	16
linch	13.5
Fellows	
height	6
breadth	5
Spokes	
breadth	2.1
thickness	3.8

RAI, Adye (1766), op. cit., pp. 65-7; cf. Muller *Treatise of Artillery* (1780), p. 124; Smith, *An Universal Military Dictionary...*, p. 55.

Appendix BBB. Dimensions of Limber for 8-Inch Howitzer, 1750–80

	In.
Diameter of the Wheels	46
Nave, length	14
Diameter	
body	12
middle	13
linch	11
Fellows	
breadth	3.5
height	4
Spokes	
breadth	1.5
height	3
Length of the Axletree	74
Body	
length	40
height	6
breadth	5
Arms	
length	17
diameter of the body	4
diameter of the linch	3
Length of the Shafts	94
Breadth of Do.	
behind	2.5
before	5
Height of Do.	
behind	3
before	2.5
Height of the Bolster	
middle	8
end	3
Width of the Limber	
before	24
behind	25

RAI, Adye (1766), pp. 67-8.

Appendix CCC. Dimensions of Howitzer Garrison Carriages

	1828				1844			
	10-Inch		8-Inch		10-Inch		8-Inch	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Brackets								
Top (Cast Iron)								
Length	2	2.75	2	0	2	2.75	2	0.5
Depth	0	8.0	0	6.5	0	9		6.25
Thickness	0	6.0	0	5.0	0	5.75		5.0
Bottom								
Length	6	0	5	0	6	0	5	0
Depth	1	10.5	1	9.5	1	10.0	1	10.0
Thickness	0	6.5	0	6.0	0	6.5	0	6.0
Transom								
Breast								
Length	2	0	1	7.5	2	0.5	1	7.5
Depth	1	3.75	1	2.5	1	4.0	1	3.0
Thickness	0	6.5	0	6.0	0	6.5	0	5.5
Horizontal								
Length	2	0	1	7.5	2	0	1	7.5
Depth	1	5.0	1	2.0	1	5.0	1	2.0
Thickness	0	6.0	0	5.0	0	6.0	0	5.0
Axletree								
Length of Bed					3	0.5	3	0
Breadth					0	7.75	0	7.75
Thickness					0	9.5	0	9.5
Length of Arm					0	10.75	0	10.75
Diameter					0	7.5	0	7.5
Trail-Bearing (Cast Iron)								
Length	0	11.5	0	11.5	0	11.5	0	11.5
Depth	0	4.75	0	4.75	0	4.75	0	4.75
Thickness	0	4.0	0	4.0	0	4.0	0	4.0
Trucks								
Diameter					1	7.0	1	7.0
Diameter of Hole					0	7.5	0	7.5
Width of Sole					0	6.625	0	6.625
Weight Cwt.	16		13		16		13	

Spearman The British Gunner (1828), pp. 115-16 and (1844), "Car," unpaginated.

Appendix DDD. Dimensions of Block Trail Carronade Carriages, 1828 and 1844

Calibre	68		42		32		24		18		12	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
I												
Trail												
Length	7	0					5	2	5	0	4	6
Width	2	1.5					1	4	1	3	1	0.5
Thickness	1	3						11		11		10
Bearing												
Length	1	8					1	6	1	6	1	4
Width	1	0						10		9		8
Thickness		8						5.5 [?]		7.5		7
Axletree Fore												
Depth		10.75						10		9		9.25
Breadth		7.75						8		7		6.75
Total Length	4	5					4	2	3	7.5	3	3
Weight Cwt. Qr. lb.	17 / 1 / 25						7 / 3 / 21		4[?]/ 3 /20		6 / 1 / 0	
II												
Block												
Length	7	0	5	10	5	6.5	5	1.5	5	0	4	6
Width	2	1.5	1	6	1	5.5	1	4	1	3	1	1
Thickness	1	1.5	1	0		11.5		11		10.5		10
Bearing (cast iron)												
Length	1	10	1	5.5	1	5	1	5	1	4.5	1	3.5
Width		10		10		10		10		9.5		9
Thickness		9		9		9		9		9		9
Axletree, Fore	4	2	3	11.5	3	10.5	3	7	3	6	3	3
Length of Bed	2	5	2	2.5	2	1.5	2	0	1	11	1	9
Depth of Bed		10.5		10		10		10		9		9.75
Breadth of Bed		7.5		7.5		7.5		6.5		6.5		5.5
Length of Arm		10.5		10.5		10.5		9.5		9.5		9
Diameter of Arm		7.5		7.5		7.5		6.5		6.5		5.5
Trucks, Fore												
Diameter	1	7	1	7	1	7	1	6.75	1	6.75	1	6.25
Diameter of Hole		7.5		7.5		7.5		6.5		6.5		5.5
Width of Sole		6.6		6.6		6.6		5		5		4.25
Weight Cwt.	17.75		10.5		9		8		7		6.25	

I, Spearman The British Gunner (1828), pp. 49, 114; II, Spearman (1844), op. cit., "Car," unpaginated.

Appendix EEE. Richardson's Description of Gun Carriages, 1859

Garrison Carriage

The Garrison Carriage is composed of the Cheeks or Brackets connected together by an Axletree Transomes and Iron Bars. The Front Transome connects the two cheeks together in front and is placed as high as possible consistently with allowing the gun to be depressed. It is inclined slightly to the rear. The rear transome serves as an axletree and also supports the elevating screw. The extremities are dovetailed on their upper surfaces and mortice holes are cut in the cheeks to fit. Either extremity of both axletrees is turned circular so as to form an arm, and is provided with an Iron Plate or clout fastened underneath to take the bearing of the Iron Trucks. Each Bracket is generally composed of two pieces secured by Dowels and by 5 bolts on each side. The front bolt passes through the axletree bed and the rear through the rear transome. These two are pinned underneath. An Iron Band below each Bracket receives the axletree. A bolt called a transome bolt passes through the Brackets and Transome and is rivetted on the outside. Another bolt called the bed bolt passes between the two brackets and is rivetted in a similar manner.

The upper surface of these carriages have an ovolo or quarter round and 4 steps to facilitate raising the Breech by Handspikes. A stool bed rests on two Iron shoulders projecting from the inside of the front Transome, and on the head of the elevating screw. The trucks are generally made of Iron, the front ones having a greater diameter than the rear. The elevating screw works in a female one of gunmetal let into the rear transome; it is provided with horizontal radiating teeth on the top and a movable bent lever with corresponding teeth. The head of the screw is hemispherical and rests in an oblong plated slot in the stool bed to admit of the play required for elevation and depression.

Capsquares are not used in the ordinary Garrison carriages.

Traveling Siege Carriages

The object of this carriage is to combine the means of transport of Heavy Guns with the appliances for firing them. It consists of the body of the carriage and the Limber. The body of the carriage is composed of two long Brackets, an axletree, front transome, elevating screw bed, the step and rear transome all of which connect the two brackets together, and two wheels.

The front transome is let into the Brackets in a slightly inclined position close to the front. The elevating screw bed is placed horizontally connecting the Brackets underneath the Breech when the Gun is in the firing trunnion holes.

The step is a small piece of wood also let in horizontally into the brackets a short distance behind the elevating screw bed and is placed there for the convenience of the man laying the gun. The rear transome, likewise in a horizontal position, connects the rear of the brackets and through it is bored the hole for receiving the pintail when limbered up.

The axletree bed and arm are attached under the fore part of the bracket on exactly similar principles to those of a Field Gun.

There are two sets of trunnion holes in the Brackets, one for the position of the gun in Action when unlimbered, the other set, in rear of the first, for the purpose of dividing the weight more equally beween the gun and limber wheels when limbered up for travelling.

The limber consists of an axletree bed and arm and a light framework of futchells. There are no limber boxes it being merely intended for purposes of draught. The shafts are movable in vertical planes on an iron rod to protect the Shaft Horse from unequal strains. The gun wheels are considerably larger than those of the limber.

The Elevating Screw works in a female screw let into the bed.

Traversing is accomplished with the aid of handspikes.

A straight pintail fixed on the top of the limber axletree bed fits into the hole through the rear transome and for security a keep chain is fastened round the projecting part of the pintail and hooked into itself. A heavy draught chain connects the limber with the remainder of the carriage and takes the strain of draught off the pintail. There are no capsquares to the travelling trunnion holes. The front and upper edges of the brackets are protected with Iron Plates fastened by bossheaded bolts and die dog nails.

68-Pounder 112 cwt Rear Chock Carriage

The Rear Chock Carriage is constructed on similar principles to the ordinary Garrison carriage with the exception that instead of having the rear transome made for trucks it lies flat on the platform. For the purpose of running up, there is a small iron socket projecting from the rear of the carriage to receive the tooth of a rolling handspike, a long lever with two lignum vitae trucks acting on an arm close to the tooth; this lever is of such power that one man can raise the rear of the carriage and throw the weight onto these trucks. The gun is run up by applying handspikes under the axletree arms as in an ordinary carriage.

The advantages of this description of carriage are: — that the recoil is much less, steadier and consequently less destructive in its effects on the platform. It is almost as easily run up as the ordinary carriage and the traversing is quicker and more accurate.

It would not be so easy to manage however unless the platform were good in the first instance.

9-Pounder Axletree and Axletree Bed

The Axletree is made of wrought Iron and consists of 3 parts viz.^{t}. The Body and 2 Arms.

The Arms are those portions which project from the main piece and are alike for both heavy and light Axletrees Length 14" to the Lynch pin hole Diameter 3" at shoulder 2" at Lynch pin hole. The size of the Lynch Pin Holes is 3/4" x 1/2". The end of the arm varies in length but commonly projects 1" from front of the Lynch pin hole, in which case the total length of arm would be 15 3/4".

The body of the Axletree is 3' 8" long. Dimensions, at the centre being 3 3/4" x 1 5/8" and at the shoulders 3 1/4" x 3 3/4". In the center is a bolt hole 1" in diameter and two other bolt holes are placed 7 1/4 inches from its centre and of the same diameter. They are used when the axletree is fitted to the gun-carriage. Two smaller bolt holes 5 1/2" from the center of the center bolt hole and 7/8" diameter are used to fit the Axletree to the limber.

The Axletree arms have a set of 3/8" upwards (measured at the shoulder by drawing a line between the lynch pin holes[)].

They have also a set to the front of 1/8" The faces of the shoulders are cut perpendicular to the center of the Axletree arms. A glance at the Figures will better explain the sets.

The Axletrees above described are used for all guns as far as 24 Por and for Ammunition Waggons.

The Axletree bed is usually made of oak for Gun carriages and of Elm for Limbers.

Dimensions: — Length 3' 8" — Depth 7" in front 6" in rear x 7" top and bottom.

The Axletree bed therefore slopes to the rear in action but when limbered up for travelling, becomes horizontal. The faces of the shoulders are cut perpendicular to the Axletree Arm.

The following Bands Plates &c are used to connect it with the Axletree, Trail &c Looking at the Isometric plan and commencing at the left the first Iron Band is termed a "clip" of which there are two on the bed. It is made of 1/4" Iron 1 3/4" wide, it goes round three sides of the bed, the ends being welded round and tapped as a screw. These ends are confined underneath by a "Buckling Plate" made of Iron of the same thickness and fastened to them by means of nuts, screwing on to the ends of the Clips which pass through holes in the Buckling Plates.

The 2nd & 4th Plates we come to are known as Jack Plates of which there are 4 (two on either side) They are made of 1 3/4" Hoop Iron and are put on to the bottom of the bed with a return of 2". Each plate is fastened by 4 screws and on the under side, dents are made to receive the teeth of the Lifting Jack.

The Irons between the Jack Plates are called Axletree Box staples and are formed of 1/4" Iron 1 1/4" in Breadth having a shoulder on the top of the side with a screw projecting from the center.

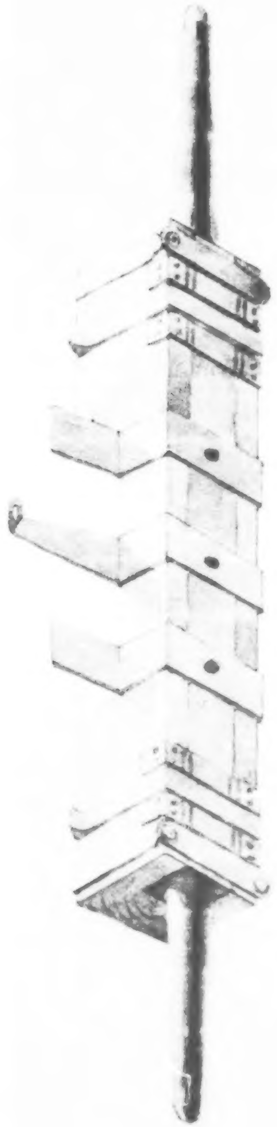
The two broad Irons on each side of the center piece of all are termed axletree bands. They are made a little smaller than the axletree bed, are put on hot & allowed to burn the wood a little so that when contracted by cooling they fit quite tight. Their Dimensions are Breadth 3 1/4" 5/8" Iron Projection of Shoulder 5". They are attached to the trail by 3 bolts the center one of which passes through the axletree.

The center Iron of all is termed the "Center Trail Plate" Dimensions. Breadth over

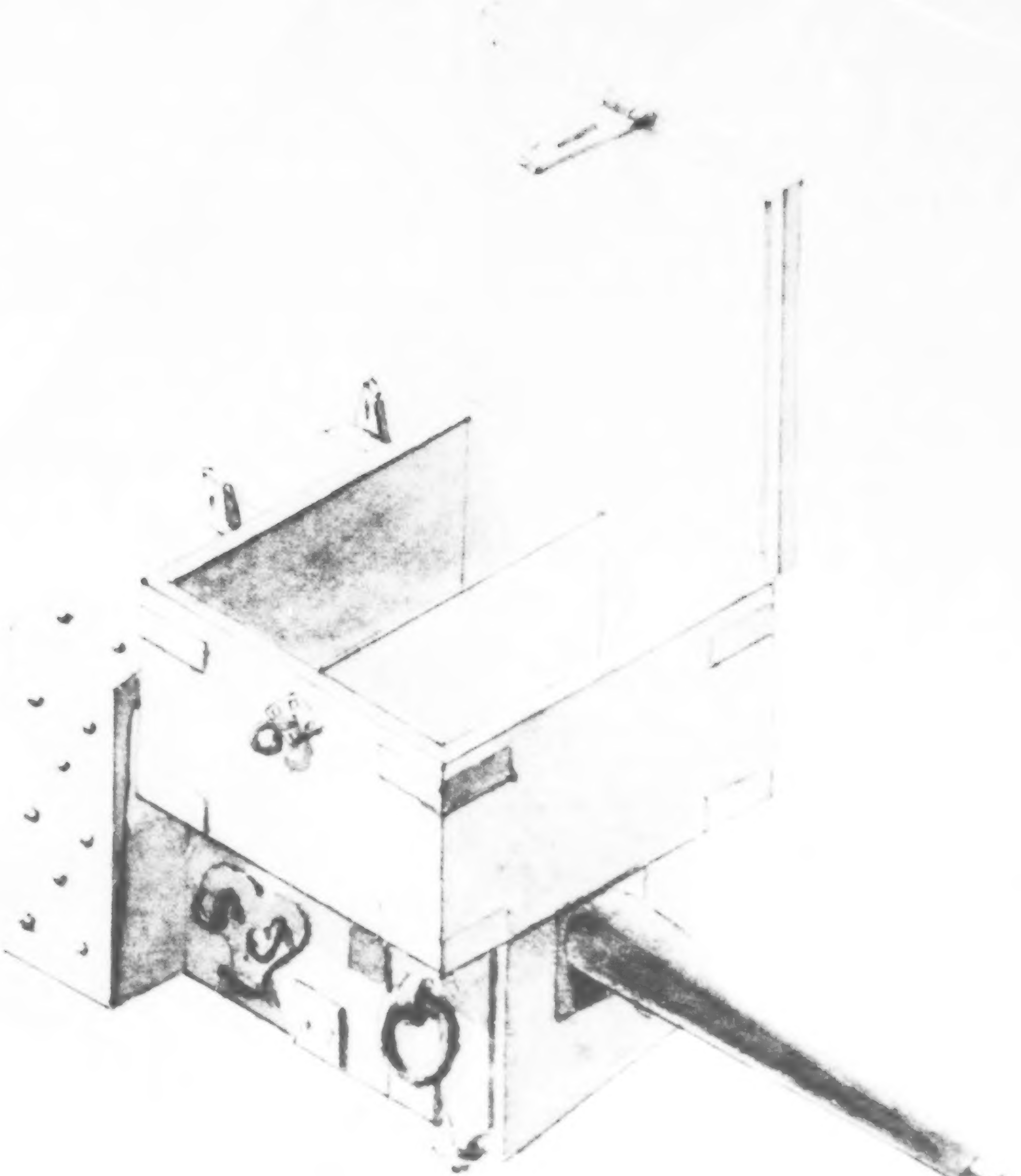
Axletree 3" Length of shoulder 7" to neck. Breadth of neck 2" 5/8" Iron. The distance between the center of Trail plate to center of either Band 7 1/8" Length from Shoulder of Axletree Arm to center of Buckling Plate 1 1/2". Ditto to center of Axletree Box Staples 5". The Jack Plates fit close on either side of the above.

The left Axletree Box is fastened on the left end of the Axletree Bed close to the shoulder by means of the Axletree box staples; the screws of the latter projecting inside and fixed by two forked[?] nuts.

The Front Rear and Top of the Box are made of fir 1" wood, the bottom and sides of Elm 1" wood. The interior is divided in two unequal portions by an Iron plate from Front to Rear. It is first nailed together and then strengthened by 8 corner plates being screwed on.



The lid and the slow match or smaller and lefthand portion of the box are copper lined also there is a 1/4" extra lining on the lid to make all safe.



The lid externally is covered with canvas fastened by strips of leather and tacks & at the back of the box, the canvas is prolonged so as to form an apron, which is plated with sheet Iron so as to protect it from the fire of the slow match. The box is closed by means of a turnbuckle and screw and a hasp on the lid.

Internal Dimensions of the box Depth 5 3/4" Breadth 10 1/2" Width 9 3/4". The Right Axletree box is similar in most respects to the left with the exception of the sheet iron partition and flap. It is not copper lined.

Dimensions Depth 5 3/4" Breadth 10 1/2" Width 10".

The corner plates of both have a return of 2 1/2". Small metal plates are placed in the center, front and rear to prevent damage from the axletree box staples.

The Turnbuckle is fastened to a diamond shaped plate which is screwed to the front center of the Box by 4 "3/4 Strong 3/4 indecipherable " screws. The hasp is 4 1/2" long averaging 1" wide.

2 Breast Chains (2'9" long 1/2" Iron) are attached to the Axletree Bed by means of two Eyebolts. They have rings at their ends.

Field Gun Carriage

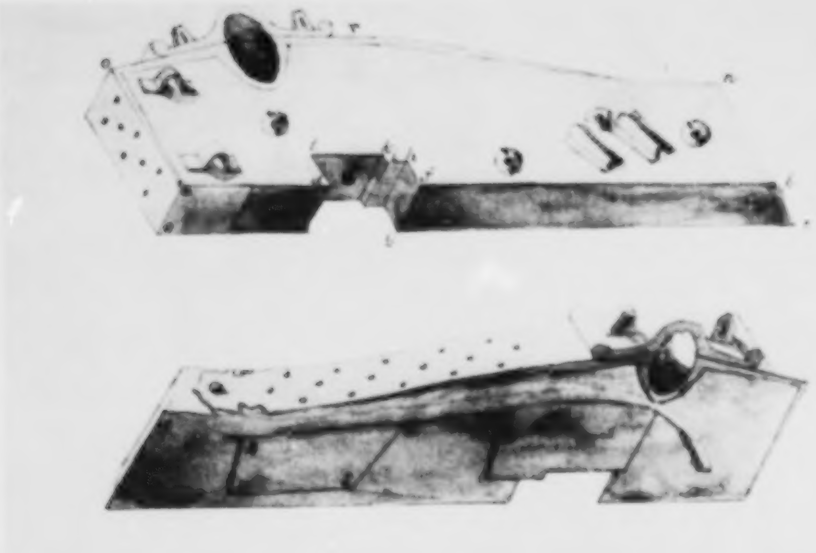
The cheeks or Brackets are made either of oak or elm and are attached to the trail by means of "housings" to enable them to resist damp and to strengthen the whole, and also by 3 bolts running horizontally through both brackets & trail

Dimensions (vide Isometric Plan)		
Thickness. ac. de &c		4"
Length ct	4'.	1 1/2"
ab	3'.	10"
Diameter of Trunnion Hole pq		3 7/8"
Length of op		8 3/4"
Depth ao		10 1/2"
Depth bn		8 1/2"
Extreme Do. fr	1'.	1."

The top is curved from r gradually down to n.

The following are the dimensions of the housing cut to fit the axletree bed

dl	2 3/4"
lk	5 1/2"
ki	1/2"
ih	1 1/2"
hf	2 1/4"
Total Breadth df	7"
ad	11 1/2"



The Bolt hole S is in the center of the housing. An Iron plate is fixed on the front and top of the Brackets called the "Trunnion Plate." The Return commences 6" from the Axletree Housing and ends about 2' 6" from the rear of Trunnion hole The Thickness of Iron commences at the end of the return with 1/8" at O it is 3/8", at p 1 1/2" at q 7/8". From q it gradually becomes thinner till it terminates at 1/16". It is attached to the Bracket by 8 Die Dog nails (see Diagram) in front, 2 Die dogs in front of the trunnions, and by 15 die dogs and two boss headed bolts in rear of the same. The three bolts u, v, w are termed Bracket bolts, having their ends countersunk into Brackets and fastened by Forked nuts 2 3/8" diameter. The diameter of each bolt is 1 1/8"

Position of center of u — 10" from ao 5 1/2" from ad
Position of center of v — 2" from fb 6 3/4" from fh
Position of center of w — 4 1/2" from fb 4" from nb.
2 Hammer Loops xx of sheet Iron — fastened by 4 screws each are placed 5 1/2" apart & 1" each from front of Trunnion plate. 2 Portfire stick loops yy having a lanyard hook between them are fixed about 11" from bn 4 1/2" long

The following are the dimensions of the housings depicted on the lower figure
α β = 8 1/4" β γ = 5" y = 9" yδ = 9 1/4"
δ ε = 6" ε = 7 3/4" = 6 1/4" = 2 3/4"
= 3/4" = 5 7/8" = 6"

A moulding runs along the top of the housings varying in breadth from 2" to 2 3/4" & fits tightly to the top of the trail assisting in keeping out the wet. The plate shews [sic] the position of the die dog nails & mentioned in the description of the upper Figure.

The Capsquares fit onto two eyebolts which pass through the Bracket and are fastened underneath by nuts

The length of the front bolt is 16" and that of the rear 18 1/2" from the shoulder to the end. The bolt portion is made of 1" Iron

The dimensions of the Capsquares themselves may be seen from the following diagram and they are secured to the Eyebolts by spring keys attached to the Brackets by chains of 1/8 Inch Iron.

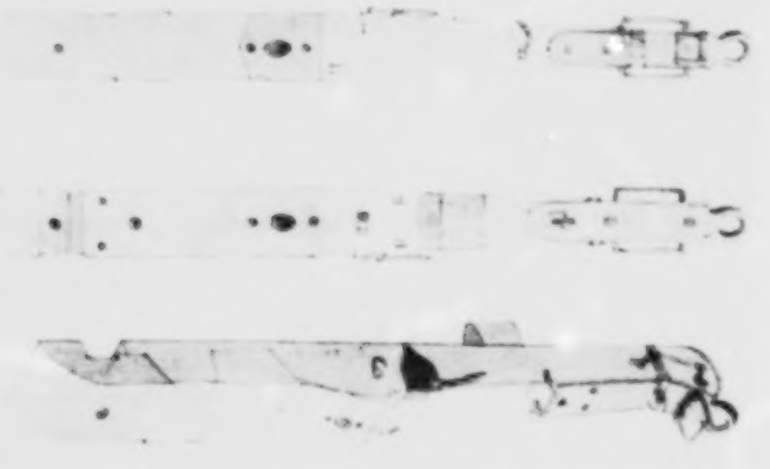
The Trail is made either of oak or Teak and is occasionally made in two pieces should the soundness of the wood be doubtful. Teak trails are the heaviest but they resist the effects of wet better than oak.

The end of the Trail is turned up and the top and bottom rounded off with an Iron plate termed the Trail Plate. On either side are placed handles to assist in limbering up. A ring is attached to the Trail plate and a "shoe" to receive the Handspike. Under the Trail is a leathern shoe to receive the spare side arms. Near the Top of the Trail are two "Locking Plates" to prevent injury to the wood from the Wheels in turning A portfire cutter is attached to the Trail near the locking plate by means of 3 screws and various small staples are let into the Trail to receive leathern Straps for securing Side Arms &c.

Dimensions

Total length ab		9'	"7"
Length of Wood work bl		9'	"1"
Length	db		6"
Length	hd		7"

The housing are cut to fit the brackets from which the dimensions may be taken



Length to Cushion	bj	3'	1"
do of do	jk		8 1/4"
do to Locking Plate	bm	5'	9"
Breadth	cb		10"
do	jo		10"
do	kp		10 1/2"

From kp the breadth of the Trail gradually diminishes to

	ql		6 1/4"

5" from the end cb the top of the Trail commences to be rounded off

A bolt v to attach the Axletree bed to the Trail passes through the latter 7" from the end

Depth	vd	7 3/8"
Depth in front of cushion	JJ'	7"
do do rear do	kk'	10 1/4"
do do do	rr'	8"
from whence it gradually diminishes in breadth to	SS'	6"

when it again widens.

In the cushion 4" from pk is a hole to allow of the insertion of the Elevating Screw having two holes on each side to allow the plate of the oscillating box to be screwed to the trail

t is the Drag chain Hook.

The edges of the Trail from the cushion to the rear are slightly bevelled off

The Portfire cutter plate is put on 3" from r and is of the following dimensions as may be seen in the plate. The point of the plate reaches the bottom of the trail and has a return of 1 1/2" on the top side.

The breadth of the Locking plate is 6 1/2"

The greatest thickness of the Trail plate is 1" and it tapers to 1/4".

Length of plate underneath	2' 3"
do do above	2' 1"
The Trail Eye projects from the wood	6"

The trail Eye is not circular inside, its axes being 2 3/4" lengthways 2 1/2" across.

7" from the end of the Trail plate eye is the Handspike loop socket which has a shoulder 1/4" on each side to prevent the loop falling backwards; the socket goes through the Trail plate and is rivetted underneath

Breadth of socket	3 1/4"

The loop is made of 3/4" Iron 4" square inside, Outside socket included 5" do [square]

The handles are put on parallel to the top of the Trail 14" from the point of the plate and are made of 3/4" Iron Their breadth inside is 8 3/4". The iron is flattened 2" at each extremity. One rivet passing through the flattened ends of each handle fastens them to the trail. The fronts of the handles are 2 1/4" from the top.

The Handspike shoe passes over the Trail Plate and has returns down the sides of the Trail 2" wide at top 1 1/2" at bottom The shoe is 2 3/8" high in rear & 2" in front and has a small hole at the top to receive the pin when the handspike is shipped. It is 18 1/2" from the end of Trail Eye

The Sponge loop 4" wide x 4" high, is made of 3/4" Half round Iron, put on 4" from the beginning of the Trail plate being fastened by screws through its ends which are flattened to the top and side of the Trail.

The Leather Shoe for side arms is 5" deep x 6 3/4" long but sometimes varies slightly

3 Bolts secure the Trail plate to the woodwork of the Trail

The center of the first is 2 1/4" from the end of the Trail Plate and on the under side terminates in a loop to which the Drag Chain is attached. The ends of the other bolts are countersunk. The second bolt is 9" from end of Trail plate. The third 7" from back of handspike Shoe.

There are also 7 countersunk nails in the Trail plate.

The Handspike key Chain Staple is driven in 2" in front of the shoe to the wood, at the side of trail plate. The Chain is 6" long & has 6 links, terminating in a 1" ring; Key 4" long 1/2" Iron

The bolts xy are to strengthen the trail

The size underneath of the elevating screw hole is 4" x 2 1/2"

The Drag Chain is made of 1/2" Iron and the hook to the eye of 3/4" Iron

A chain of 4 links 2 1/4" inside is fastened to the eye of the first rivet of trail plate and then a ring is attached to hook the dog to. After which a chain of 12 links 2 1/4" and then an 8" long loop with a 'Dog' and 'Keeper' running in it, 14 links with another 8" loop and Dog and Keeper are attached to this. The total length of the chain is 7'6"

The Elevating Screw works in an oscillating box attached to the Trail by means of a plate and two bolts. On either side of this plate are Gun Metal Brackets having holes in these similar to the Trunnion holes. The Tumbler through which the Elevating screw passes is a rectangular piece of gun metal having two arms like trunnions which work in the Brackets. This arrangement allows the Elevating Screw a certain play The Elevating Screw passes completely through the Block Trail its length being 19" for the 9 Por.
Dimensions of the oscillating box &c.

Length of Flange [?] Plate	BC	6 1/2"
Breadth of do	BD	8 1/2"
Depth	CG	3/4"
Length	EF	10 4/5"
Breadth	BH	2"
do	BI	1/2"
Height	JK	2"
Height of Oscillating Box	LM	2 1/4"
Length	EN	3 1/4
	EX	1 7/8
Diameter of hole xx in centre of	DB	1 1/8"

The oscillating Box is made in two pieces the top being screwed on to the bottom by 4 screws.
The top is 1/2" deep.

Side of Box	LP	4 3/4"
do do	MQ	4"
Diameter of Trunnions		1 1/4"

In the center of the top of the box is a circular hole 1/2" deep 3" in diameter to receive the shoulder of the Elevating screw which has the arms attached.
A Female screw is tapped through the remainder of the box, diameter 1 1/2" and has a pitch of 3 threads in every 1 1/8" Breadth of Screw 9/40"
The shoulder to which the horns are attached fits into the Circular hole 1/2" deep before mentioned, the female screw continued through it

Total depth of Female Screw	2 3/4"
Height of Shoulder	1 3/4"

There are 4 horns attached to the shoulder Length 5 1/2" from the center of the shoulder for the purpose of giving leverage in raising the Elevating Screw.

Distance of the bolts in Brackets from ends	1/4"
Height of Brackets from Flange [?] Plate	2"

The Flange[?] plate is made of cast Iron and is connected with the Trail by 2, 1" bolts through xx and x'x'

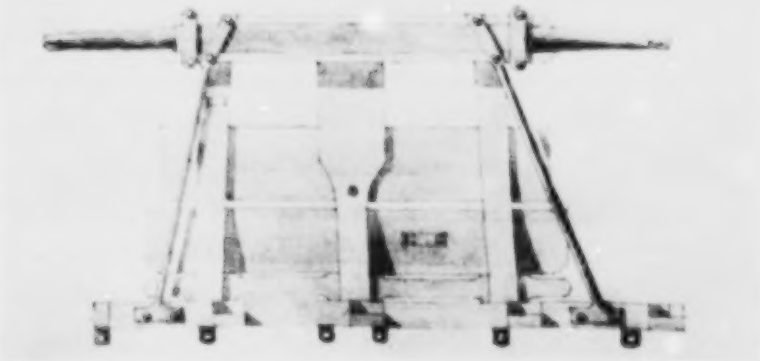
The Elevating Screw has a diameter of	1 7/8"
Pitch 3 threads in every	1 1/8"
Length	19"

It has a loop at the top to attach it to the button, which is effected by means of a bolt passing through 2 holes in the button and the loop and is secured by a nut

Limber Bed

The Limber is composed of an axletree bed of Elm and three futchells made of ash. The axletree fits into a groove in the bed and is secured there by 2 bolts, one on each side of the centre futchell, which pass through it and the bed and are rivetted underneath At the extremities of the bed there are buckling plates fastening the ends of coupling plates.
The axletree is similar to the Gun axletree.
The three futchells connect a piece of wood called the "Splinter bar" with the Axletree bed.

This connexion is also strengthened by means of 2 arms of Iron secured underneath the axletree bed and close inside the Buckling plates at one end, the other end being bolted near the extremities of the splinter bar. A piece of wood, termed the "Slat," shorter than the splinter bar lies close behind it, parallel to it, and on top of the 3 futchells, and is fastened to the futchells and splinter bar by means of Iron Plates on the top of the Futchells and between the Axletree bed and Slat, parallel to both are two 1" Boards called the Platform Board (nearest the axletree) and the footboard, the latter inclined to the futchells and kept in that position by two pieces of wood one on either side of the futchell.



The splinter bar is so constructed as to be available for either single or double draught. It has 4 iron loops A,B,C,D. When used for single draught, the shafts pass through B & D When for double draught through A & C The eyes eeeeee are for the purpose of hooking on the traces or swingle tree as required. The Slat was added to prevent a kicking horse getting his hoof between the splinter bar and the foot board.

The stays are to strengthen the splinter bar and to throw the strain of draught on the Axletree bed and Arm

The Platform board is attached to give a place to fasten side arms to (the staples iiiii are for this purpose) and is secured to the two side futchells by means of 4 countersunk bolts

When double draught is required the off shaft passes through the splinter bar and is

fixed by a loop on the end of itself on to the axletree arm outside the wheel and keyed by the Linch Pin.
The near shaft passes through C the end of it fitting into a hole made to receive it, in the axletree bed and is keyed with a bolt passing through a hole K in the Platform Board and a hole through itself
When used for Single draught the off shaft passed through B, the loop at the end of it fitting on to a small Iron Crutch let into the Axletree Bed
The Near Shaft passes through D, the end of it fitting into a hole made for the purpose in the axletree bed, and is keyed by an Iron bolt passing through the hole L in the foot board and the hole in itself.
Small shoulders of Iron MM are fixed at the extremities and on top of the axletree bed to steady the Limber boxes, a rectangular piece of wood n is fixed in a similar position in the centre of the axletree bed and flush with the rear, for the same purpose. The Limber boxes project behind the axletree bed the support afforded by the axletree bed being enlarged by two pieces of wood nailed on
The center futchell is morticed and the side futchells housed into the axletree bed Various Loops, Straps &c are fastened to the bed to attach the side arms
The above diagrams being drawn to scale the various dimensions may be found by measurement[.]

The principal parts of the wheel are the "Nave," the "Spokes" the "Felloes" and the "Tire."
The nave is made of Elm. A cylindro-conoidal hole B running in the direction of its axis is made to receive the axletree arm; this hole is lined with iron pipe box C to protect the wood from friction and consequent wear and tear. The internal diameter of the Pipe box is slightly increased at the center to admit grease 12 mortice holes DD are cut in the Nave, radiating from the axis, to contain the spokes EEE which are driven in by mechanical power. These spokes 12 in number (made of oak) connect the nave with the remaining fundamental parts of the wheel.
There are 6 Felloes of ash FF&c. which form the circumference of the Wheel. Finally the Felloes are protected by a "Tire" composed of 6 "Streaks" of Wrought Iron. The extremities of the Streaks and Felloes do not coincide but overlap each other halfway to increase the strength of the whole. The outer extremities of the spokes are cut to fit mortice holes and secured by oak wedges GGGG&c are bolts 1" in diameter to prevent the Felloes from splitting when wedging the spokes. Each Felloe has a dowel at one end fitting into a hole in the next felloe. The inner edges of the felloes are bevelled. The Tire is put on hot in order, by contracting to draw the Felloes into close contact. Each streak is attached to the Felloes by 6 Iron bolts. All wheels in the service are constructed with a disk of 1/4" to a foot....
A nave hoop is placed on either end of the nave to prevent the wood from splitting, when driving the spokes and afterwards....
In our service shafts are used for draught as they afford greater facilities than the pole for turning. They are termed "Near" & "Off"

The total length of the near shaft is	9' 7"
The total length of the off shaft is	9' 5"

Source: RAI, J.B.S. Richardson, Account of Long Course at Shoeburyness, 1859-60. Bound MS, unpaginated.

App. FFF. Dimensions of New Oblong Hammered Iron Carcasses

	Side Bars		Bottom			Centre Bar			Top			
Nature of Carcass in.	Breadth in.	Thick. in.	Greatest Diam. in.	Thick. in.	Depth in.	Breadth in.	Thick. in.	Inter. Diam. in.	Greatest Diam. in.	Thick. in.	Depth in.	Dist. from Bottom in.
18	2.25	.375	17.375	.375	5.75	2.25	.375	15.25	13.5	.375	2.0	16.0
13	1.75	.375	12.0	.3125	4.0	1.75	.375	11.0	10.375	.3125	2.75	9.0
10	1.5	.312	8.75	.3125	3.125	1.5	.3125	8..5	8.0	.25	3.0	7.125
8	1.25	.25	7.375	.25	3.0	1.25	.25	6.9	6.625	.2	1.6	5.75
5 1/2	1.0	.1	5.25	.1	2.25	1.0	.1	4.75		These have		
4 2/5	.75	.1	4.2	.1	2.0	.75	.1	3.8		no tops		

	Diameter			Ears		Diameter of Oblong			Centre Bar					
Nature of Carcass in.	Side Holes in.	Centre Hole in.	No. of Holes in Top in.	Ext. Diam. in.	Thick. of metal in.	Inter. Conjugate ft.	Inter. Conjugate in.	Inter. Transv. in.	Dist. from Bottom in.	Thick. of side barrs in bottom in.	Total Length Ext. ft.	Total Length Ext. in.	Diam. at centre & barr Ext. ft.	Diam. at centre & barr Ext. in.
18	1.5	2.75	5	1.75	.5	2	0	15.2	3.5	1.0	2	0	1	5
13	1.25	1.75	5	1.75	.375	1	4	11.0	3.0	.75	1	5.0	1	
10	1.0	1.5	5	1.75	.375	1	0.75	8.5	2.25	.3	1	2.125		9.25
8	.8125	1.25	5	1.25	.3125		10.25	6.875	2.0	.25		11.25		7.5
5 1/2							7.5	4.75	2.0			7.625		5.4
4 2/5							6.25	3.8	1.1			6.25		4.125

Slightly adapted from RAI, Walton, "Gunnery Tables 1780-1792...," unpaginated.

Appendix GGG. Dimensions of weight of round Carcasses, as established the 2d. of August, 1760.

			Diameter of the Holes				Side Holes		Thickness of Metal				
	Diameter		Top		In the Sides								
Nature of Carcass	Exterior in.	Interior in.	at top in.	at bottom in.	at top in.	at bottom in.	From the top hole in.	From each other in.	At each Hole in.	At bottom of Carcass in.	Weight c.	q.	lb.
5 holes	12.75	8.2	3.4	3.25*	2.4	2.3	6.2	7.0	2.0	2.55	1	2	14
4 holes	12.75	8.0	3.5	3.3	2.5	2.2	6.2	10.85	2.0	3.0	1	2	26
3 holes	12.75	7.5	4.0	3.8	2.8	2.6	6.2	12.0	2.0	3.25	1	3	4

Slightly adapted from RAI, Adye (1766), op. cit., p. 89 and Smith, op. cit., p. 287.

Appendix HHH. Partial Dimensions of 20 Shot Grape Shot.

Nature	Iron Shot			Pin	Bottom		Bag			Line			Total Weight	
	Weight lb.	oz.	Diameter in.	Height in.	Diameter in.	Thickness in.	Length in.	Breadth sewed in.	Breadth Cut out in.	Length Y.	F.	L.	lb.	oz.
42 pdr.	2	0	2.42	9.15	6.68	0.61	17.5	18.7	20.2	5	1	6	46	6
32	1	8	2.20	8.31	6.1	0.55	15.9	17.1	18.6	4	2	8	34	1
24	1	0	1.92	7.26	5.54	0.48	14.2	15.1	16.3	4	1	0	25	2.5
18	0	13	1.8	6.60	5.03	0.44	12.8	14.0	15.2	4	0	0	19	15.5
12		8	1.52											
9		6	1.38											
6		4	1.21											
4		3												
3		2												

Notes: The height of the pin may not include its head.
Later weights for 32 and eight 1-pdr. grape was 31 lb. 1 oz. and 19 lb. 5.5 oz. respectively.

RAI, Walton, "Gunnery Tables 1780-1792..." unpaginated; RAI, Frazer, "Laboratory Work," p. 17. Frazer includes the calibres of 12-pdr. and below.

Appendix III. Dimensions of Quilted Grape Shot (9 shot), 1750-1800)

Nature	Iron Shot			Tampeon									Bag			Line			Total Weight	
				Pin				Bottom												
	Weight		Diam.	Height of Body	Height of Head	Diameter of Body	Diameter of Head	Diameter	Thickness	Weight			Length	Breadth Sewed	Breadth Cut Out	Length		Circ.		
	lb.	oz.	in.	in.	in.	in.	in.	in.	in.	lb.	oz.	dr.	in.	in.	in.	ft.	in.	in.	lb.	oz.
42 pdr.	4	0	3.052	9.156	0.29	0.58	1.16	6.684	0.61	6	9	4	17.5	18.7	20.2	10	1.3	0.96	42	15.5
32	3	0	2.773	[illegible]19	0.28	0.559	1.118	6.105	0.554	5	0	0	15.9	17.1	18.6	9	2.5	0.85	32	14.5
24	2	0	2.422	7.266	0.35	0.702	1.404	5.546	0.484	4	0	6	14.2	15.1	16.3	8	1	0.75	23	1
18	1	8	2.201	6.603	0.32	0.637	1.374	5.039	0.44	3	0	6	12.8	14.0	15.2	7	4.3	0.69	17	3
12	1	0	1.923	5.769	0.28	0.556	1.112	4.402	0.384	1	15	14	11.2	12.3	13.5	6	4.8	0.60	11	0
9		13 1/8	1.8	5.40	0.20	0.40	0.80	4.0	0.36	1	10	12	10.4	11.2	12.4	5	11.9	0.56	9	2
6		8	1.526	4.578	0.221	0.442	0.884	3.48	0.305	1	0	8	8.9	9.7	10.7	5	1	0.47		
4		6	1.386	4.158	0.14	0.28	0.56	3.052	0.273	0	8	13	7.9	8.5	9.5	4	7.2	0.41		
3		4	1.211	3.633	0.175	0.351	0.702	2.773	0.242	0	6	10	7.1	7.7	8.7	4	0.5	0.38		
1 1/2		2	0.961	2.88	+	0.279	+	2.201	0.192	0	3	15	5.6	6.1	6.9			0.28		
1		1 1/2	0.873	2.619	+	0.177	+	1.923	0.174	0	2	8	4.5	5.3	6.1			0.25		
1/2*		3/4	0.693	2.079	+	0.139	+	1.526	0.138	0	1	2.5		4.2	5.0	2	3.4	0.19		

* Lead shot + no heads

This table was prepared from a number of notebooks; RAI, Glegg, op.cit., pp. 15-16; RAI, "Artillery Experiments 1770-1; 1773," unpaginated; RAI, Meridith, op. cit., p. 31; RAI, Walton, op. cit., unpaginated; RAI, Frazer, "Work Notes," pp. 87, 89, 91.

There were minor variations between the various notebooks.

Appendix JJJ. Dimensions of Quilted Grape Shot, circa 1845.

Nature	Shot			Tampion				Line Length		Bag			Total Weight	
				Pin		Bottom								
	No.	Weight		Length	Diameter	Thickness	Diameter			Width	Length	Width Finished		
		lb.	oz.	in.	in.	in.	in.	ft.	in.	in.	in.	in.	lb.	oz.
68 pdr.	15	3	0	9.6	.75	.64	7.78	12	6	23	17	10 5/8	50	8
56	12	3	0											
42	9	4	0	9.15	.668	.61	6.68	10	0	20	16	9.5	42	9
32	9	3	0	8.31	.6	.55	6.1	9	2	19	14.5	8.5	32	0
24	9	2	0	7.26	.554	.48	5.54	8	1	16.5	13.5	7.75	22	9
18	9	1	8	6.6	.503	.44	5.03	7	4	14.75	12.25	6.875	16	8
12	9	1	0	5.76	.44	.38	4.4	6	5	13	10.5	6	10	15.5
9	9		13 1/8	5.4	.4	.36	4.	6	0	12	10	5.5	9	1
6	9		8	4.57	.348	.3	3.48	5	1	10.75	8.5	5	5	8.5

Slightly adapted from RMC, Noble, "Notes on Practical Artillery" (1849), p. 353; DND, Fitzhugh, "A Course of Practical Artillery" (1845), p. 269.

Appendix KKK. Grape Shot, Circa 1860

Nature	Shot					Plates				Tampion		Case		Total Weight	
	Weight of each lb.	Weight of each oz.	Number in a Tier	Number of Tiers	Total Number	Number Wrought Iron	Number Cast Iron	Diam. in.	Thickness in.	Length in.	Thickness in.	Depth in.	Diam. in.	lb.	oz.
Guns															
10 in.*	3		8	3	24	2		9.592	.165			8.1	9.82	81	7
8 in. or 68 pdr.	3		5	3	15	1	3	7.82	.5063	10.375	.75			65	9
56	4		4	3	12	1	3	7.45	.5063	11.25	.75			69	7
42	4		3	3	9	1	3	6.735	.5	10.5	.5			48	11
32	3		3	3	9	1	3	6.147	.5	9.37	.5			36	12
24	2		3	3	9	1	3	5.57	.375	8.375	.5			25	3
18	1	8	3	3	9	1	3	5.074	.3125	7.375	.5			18	13
12	1		3	3	9	1	3	4.402	.3125	6.375	.375			12	15
9		13 1/8	3	3	9	1	3	4.06	.25	6.127	.3125			10	12
6		8	3	3	9	1	3	3.532	.165	5.25	.3125			6	11
Carronades*															
68 pdr.	3		5	3	15	1		7.7	.165			7.87	7.82	46	8 1/4
42	4		3	3	9	1		6.594	.165			8.5	6.35	38	8 1/4
32	3		3	3	9	1		6.02	.165			7.6	6.147	28	3 3/4
24	2		3	3	9	1		5.44	.165			6.4	5.57	18	9 3/4
18	1	8	3	3	9	1		4.96	.165			6.0	5.074	14	6 3/4
12	1		3	3	9	1		4.34	.165			5.4	4.432	10	0

* Grape for the 10-inch gun is packed in an iron cylinder, with plate-iron end and top, with an iron handle; and, for carronades in tin cylinders with a tin end, plate-iron top, and rope handle.

Majendie, Ammunition: A Descriptive Treatise on Different Projectiles, Charges, Fuzes and Rockets, etc. ... (London, 1867), p. 324.

Appendix LLL. Dimensions of "Tin Case Grape Shot for Land Service," April 1755

	Shot					Tin Case			
	Nature	Diameter	Real Weight		Number	Exterior Diameter	Interior Depth	Length over bottom for nailing	Shot fills up
	oz.	in.	oz.	dr.		in.	in.	in.	in.
12 pdr.	1 1/2	0.873	1	8		4.4			
6	1 1/4	0.822	1	4	68	3.49	4.96	0.65	4.21
3	1 1/8	0.827	1	3.9	33		4.2	0.6	3.60
1 1/2	1 1/8	0.827	1	3.9	16		3.3	0.5	2.80

Appendix LLL. Dimensions of "Tin Case Grape Shot for Land Service," April 1755

	Parchment Cap and Case															
	Case			Cap												
	Length cut out	Length over powder fixed	Total length fixed	Length cut out	Breadth cut out	Tin Case		Wooden Bottom		Shot		Bottom Case and Shot		Powder in flannel cartridge		Total length fixed
	in.	in.	in.	in.	in.	oz.	dr.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	in.
12 pdr.	6.6	3.88	5.6	6.6	15.0			1	0					3		
6	5.45	3.05	4.45	5.45	11.83	3	14		8 3/16	5	5	6	1 1/16	1	8	13.25
3									4	2	8 11/16					
1 1/2						2	0		2 1/4	1	3 3/4					

RAI, Glegg, Notes on Artillery, circa 1752, pp. 13-14.

Appendix MMM. Dimensions of Case Shot 1766-80.

Nature	Weight of Shot	Number of Shot	Case			Bottom			Depth of Shoulder
			Weight		Length	Weight		Length	
	oz.		oz.	dr.	in.	lb.	oz.	in.	in.
42 pdr.	6 a	94	15	8	8.75	5	2	5.875	1.25
32	6 a	72	15	0	8.25	4	0	5.6	1.875
24	6 a	56	13	8	8	2	0	5	1
	4 a	85	13	8	8	2	0	5	1
	3 a	113	13	8	8	2	0	5	1
18	4 a	62	9	8	7.75	1	15	4.5	1
	3	82	9	8	7.75	1	15	4.5	1
12	2 a	84	7	8	6.25	1	1	3.5	.875
	1 1/4	134	7	8	6.25	1	1	3.5	.875
9	2 a	63	5	8	6		13	3	0.6
	1 3/4	73	5	8	6		13	3	0.6
	1 1/2	84	5	8	6		13	3	0.6
6	1 1/2 a	56	4	4	4.9		8.5	3	0.6
3	1 1/4 a	34	2	4	3.9		4.25	2.4	0.5
1 1/2	1 1/8 a	17	1	14	3.5		2.25	1.9	0.5
Howitzers									
8 in.	6 a	81	14	0	6.1	4	0	5	1
5 1/2	3	55	8	8	4.8	1	8.5	4	0.8
	2 a	70	8	8	4.8	1	8.5	4	0.8
4 2/5	2 a	54	6	8	4.1	1	0	3.5	0.7

RAI, Adye (1766), op. cit., pp. 115-16; RAI, "Artillery Experiments, 1770-1; 1773," unpaginated; RAI, Meridith, "Laboratory Notes, 1780". The notation "a" was made in the "Artillery Experiments" to indicate the shot "...most proper for Land Service."

Appendix NNN. Sea Service Case Shot, circa 1780.

Nature		Weight of shot	Number of shot	Case			Bottom			Depth of Shoulder
				Weight		Length	Length	Weight		
		oz.		oz.	dr.	in.	in.	lb.	oz.	in.
42	pdr.	13 1/8	47	15	8	8.75	1.45	1	14	.85
32		8	56	15	0	8.25	1.3		14.25	.8
24		8	42	13	8	8	2.75	1	14.25	.863
18		6	42	9	8	7.75	2.475		15	.8
12		4	42	7	8	6.75	2.360		12	.775
9		3	44	5	8	6	2.05		12	.65
6		2	40	4	4	4.9	1.975		5.25	.625
4		2	28	3	8	4.3	1.725		3.5	.55
3		1 1/2	31	2	4	3.9	1.55		1.75	.525

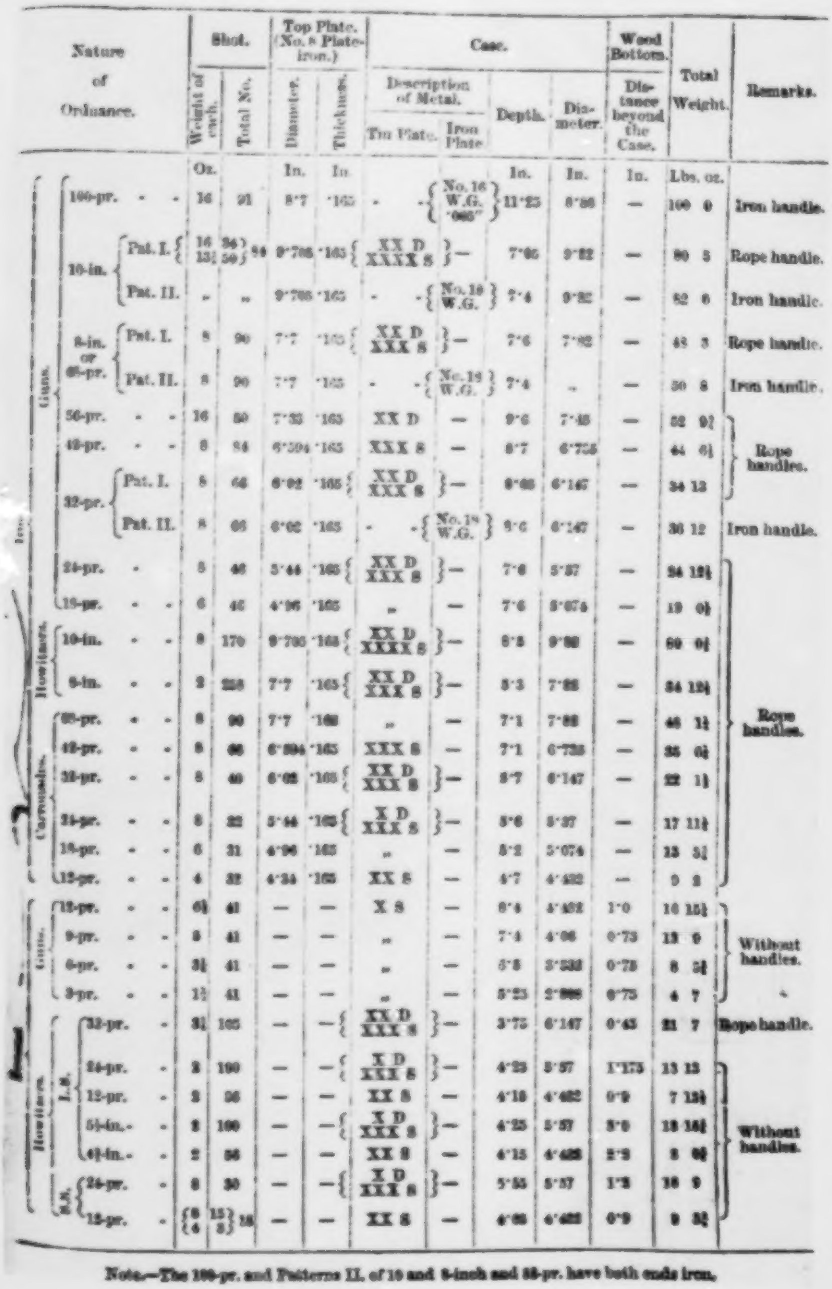
RAI, Meridith, op. cit., p. 25. Meridith does not say specifically that the bottoms are for sea service and some of the dimensions are a little puzzling.

Appendix OOO. Weight and Dimensions of Case Shot for Guns, Howitzers, and Carronades, 1828

Nature	Shot			Tampeons								Cases					Total Weight	
	Weight		No. in each	Iron				Wood				Circumference	Depth		Weight			
				Thickness	Diameter	Weight		Thickness	Diameter	Weight			Between clipts	Total				
	oz.	dr.		in.	in.	oz.	dr.	in.	in.	lb.	oz.	in.	in.	in.	lb.	oz.	lb.	oz.
Guns – Garrison and Sea Service																		
68 pdr.	8			.06	7.6	11		1.9	7.6									
42	8		85	.05	6.45	9		1.52	6.45			21.6	9.0	10.0	1	6	42	15
32	8		66	.05	5.9	7		1.32	5.9			19.8	8.3	9.5		15	33	8
24	8		46	.05	5.3	7		1.29	5.3			18.1	7.6	8.7		9.5	23	8
18	6		46	.05	4.75	4	8	1.2	4.75			16.5	7.35	8.4		9	18	14
12	4		46	.04	4.25	2	8	1.1	4.25			14.4	6.0	7.1		8.5	11	13
9	3		44	.04	4.0	2		1.0	4.0			13.2	5.3	6.3		7	8	8
6	2		40	.04	3.5	1	8	.98	3.5			11.5	4.5	5.6		5	5	12
4	3		28	.04	2.9	1		.86	2.9			9.9	5.9	6.6		6	4	
3	1	8	34	.04	2.7		12	.79	2.7			9.1	4.25	4.7		3	3	9
Guns – Field Service																		
12 pdr.	2		126	.05	4.25	2	8	1.1	4.25			14.4	7.7	8.8		11	17	6.5
	6	8	41	.05	4.25	2	8	1.1	4.25			14.4	7.63	8.7		13	15	9
9	1	8	126	.05	4.0	2		1.0	4.0			13.2	7.3	8.4		9	12	14
	5		41	.05	4.0	2		1.0	4.0			13.2	7.0	8.0		9	13	4
6	1	8	85	.05	3.5	1	8	.98	3.5			11.5	6.7	7.7		8	8	12
	3	4	41	.05	3.5	1	8	.98	3.5			11.5	6.1	7.2		7	9	
3	1	8	41	.05	2.7		12	.79	2.7			9.1	4.8	5.8		4	4	5
Howitzers																		
10 in.	8		170	.06	9.7	13						31.7	8.3	9.4	2	1	86	4
8	2		285	.05	7.6	8	8		7.8			24.8	7.6	8.6		14	35	
5 1/2	2		100	.05	5.3	4		1.29	5.3			18.1	4.5	5.7		7	14	
4 2/5	2		55	.04	4.25	2		1.1	4.25			14.4	3.7	4.8		4.5	7	11.5
24 pdr.	2		140	.05	5.3			1.29	5.3			18.1	5.5	6.5			19	4
12	2		84	.04	4.25			1.1	4.25			14.4	5.2	6.2			11	13
Carronades																		
68 pdr.	8		90	.06	7.6			1.45	7.6	1	6.25	24.5	7.7	8.9	1	4	46	2
42	8		66	.05	6.45			1.35	6.45	1	0.75	21.6	7.9	8.9	1	2	32	8.5
32	8		40	.05	5.9			1.0	5.9		7.25	19.3	5.9	7.0		11.25	21	4
24	8		32	.05	5.3			.85	5.3		6.5	17.9	5.8	6.8		10.5	16	1
18	6		31	.05	4.75			.8	4.75		6.375	15.8	5.7	6.6		7.25	12	2
12	4		32	.04	4.25			.75	4.25		4.375	13.8	4.4	5.5		5.75	8	2

Spearman (1828), op. cit., pp. 127-9; cf. RAI, Swanston, Papers, op. cit., pp. 90-1.

Appendix PPP. Dimensions of Case Shot, 1863.



Nature of Ordnance.		Shot.		Top Plate. (No. 8 Plate-iron.)		Case.				Wood Bottom.	Total Weight.	Remarks.
		Weight of each.	Total No.	Diameter.	Thickness.	Description of Metal.		Depth.	Diameter.	Distance beyond the Case.		
						Tin Plate.	Iron Plate.					
		Oz.		In.	In.			In.	In.	In.	Lbs. oz.	
Iron. Guns.	100-pr.	16	91	8·7	·165	- -	No. 16 W.G. ·065"	11·25	8·86	—	100 0	Iron handle.
	10-in. Pat. I.	16 13½	34 50 } 84	9·705	·165	XX D XXXX S	—	7·05	9·82	—	90 5	Rope handle.
	10-in. Pat. II.	„	„	9·705	·165	- -	No. 18 W.G.	7·4	9·82	—	82 6	Iron handle.
	8-in. or 68-pr. Pat. I.	8	90	7·7	·165	XX D XXX S	—	7·6	7·62	—	48 3	Rope handle.
	8-in. or 68-pr. Pat. II.	8	90	7·7	·165	- -	No. 18 W.G.	7·4	„	—	50 8	Iron handle.
	56-pr.	16	50	7·33	·165	XX D	—	9·6	7·48	—	52 9¾	Rope handles.
	42-pr.	8	84	6·594	·165	XXX S	—	8·7	6·735	—	44 6¼	
	32-pr. Pat. I.	8	66	6·02	·165	XX D XXX S	—	8·05	6·147	—	34 13	
	32-pr. Pat. II.	8	66	6·02	·165	- -	No. 18 W.G.	8·6	6·147	—	36 12	Iron handle.
	24-pr.	8	46	5·44	·165	XX D XXX S	—	7·6	5·57	—	24 12¼	Rope handles.
	18-pr.	6	46	4·96	·165	„	—	7·6	5·074	—	19 0¾	
Iron. Howitzers.	10-in.	8	170	9·705	·165	XX D XXXX S	—	8·5	9·82	—	69 0¾	
	8-in.	2	258	7·7	·165	XX D XXX S	—	5·3	7·82	—	34 12¼	
Iron. Carronades.	68-pr.	8	90	7·7	·165	„	—	7·1	7·82	—	46 1¾	
	42-pr.	8	66	6·594	·165	XXX S	—	7·1	6·735	—	35 0¾	
	32-pr.	8	40	6·02	·165	XX D XXX S	—	5·7	6·147	—	22 1¾	
	24-pr.	8	22	5·44	·165	X D XXX S	—	5·6	5·57	—	17 11¾	
	18-pr.	6	31	4·96	·165	„	—	5·2	5·074	—	13 5¾	
	12-pr.	4	32	4·34	·165	XX S	—	4·7	4·432	—	9 2	
Guns.	12-pr.	6¼	41	—	—	X S	—	8·4	4·432	1·0	16 15¾	Without handles.
	9-pr.	5	41	—	—	„	—	7·4	4·06	0·73	13 9	
	6-pr.	3¼	41	—	—	„	—	6·8	3·232	0·73	8 5¾	
	3-pr.	1½	41	—	—	„	—	5·25	2·808	0·75	4 7	
Howitzers. L.S.	32-pr.	3¼	105	—	—	XX D XXX S	—	3·75	6·147	0·45	21 7	Rope handle.
	24-pr.	2	100	—	—	X D XXX S	—	4·25	5·57	1·175	13 13	Without handles.
	12-pr.	2	56	—	—	XX S	—	4·15	4·462	0·9	7 13¾	
	5½-in.	2	100	—	—	X D XXX S	—	4·25	5·57	5·0	13 15¾	
	4⅖-in.	2	56	—	—	XX S	—	4·15	4·425	2·3	8 0¾	
Howitzers. S.S.	24-pr.	8	30	—	—	X D XXX S	—	5·55	5·57	1·3	10 9	
	12-pr.	8 4	15 3 } 18	—	—	XX S	—	4·05	4·425	0·9	9 3¾	

Note.—The 100-pr. and Patterns II. of 10 and 8-inch and 68-pr. have both ends iron.

Majendie, Ammunition... (1867), p. 323, Table III.

Appendix QQQ. Spherical Case or Shrapnel Shells, 1820-50.

Nature	No. of Musket Balls	Bursting Powder		Exterior Diameter	Thickness of Metal	Error Allowed	Fuze Hole		
							Diameter		Depth
							Top	Bottom	
		oz.	dr.	in.	in.	in.	in.	in.	in.
68 pdr.	377	15	0	7.85	.785	.131	1.22	1.1	1.9
42	261	7	8	6.65	.665	.111	1.22	1.1	1.5
32	176	7	0	6.105	.610	.101	1.22	1.1	1.5
24	128	6	0	5.5	.55	.091	.89	.77	1.1
18	90	5	0	5.0	.5	.083	.89	.77	1.1
12	63	4	8	4.4	.44	.073	.89	.77	1.1
9	41	3	8	4.05	.405	.067	.89	.77	1.0
6	27	2	8	3.55	.355	.059	.89	.77	1.0
3	11	1	8	2.79	.283	.047	.89	.77	.9
8 in.	377	15	0	7.85	.785	.131	1.22	1.1	1.9
5 1/2	128	6	0	5.5	.55	.091	.89	.77	1.1
4 2/5	63	4	8	4.4	.44	.073	.89	.77	1.1

RAI, "Equipment, Royal Arty. 1813-1819;" RAI, "Mem. of Colonel Millars 68 Pr. Gun..., p. 9; Adye (1827), op .cit., p. 348. The number of balls in the 42-pdr. shell seems to have been reduced to 240 or 241 in the 1820s; by the 1840s the number of balls in the 32-pdr. shell was increased to 204; the number in a 24-pdr. shell was often said to be either 128 or 130. The 3-pdr. shrapnel shell seems to have vanished quickly.

Appendix RRR. Service Charges and Dimensions of Cartridges, 1863

Nature of Ordnance.		Charge.	Purpose for which each Charge is intended. Land Service.	Purpose for which each Charge is intended. Sea Service.	How marked.†	Cartridges. [illegible] Length.	Cartridges. [illegible] Width. Top.	Cartridges. [illegible] Width. Bottom.	Cartridges. [illegible] Length.	Cartridges. [illegible] Width. Top.	Cartridges. [illegible] Width. Bottom.	[illegible]	[illegible]	No. Paper Cases.
		lbs.				Inch.	Inches	Inches	Inch.	Inch.	Inch.			
Guns,	150-pr.	40	-	Battering	150-pr. 40 lb.	[illegible]	20	—	[illegible]	14·37	[illegible]	3	24	—
		35	-	Full	150-pr. 35 lb.	25·25	20	—	20·65	14·37	[illegible]	3	23	—
		20	-	Reduced and saluting	150-pr. 20 lb.	[illegible]	[illegible]	[illegible]	19·4	14·875	[illegible]	3	21	—
	100-pr.	25	-	Battering	100-pr. 25 lb.	25	[illegible]	[illegible]	20·65	[illegible]	[illegible]	3	23	—
		20	-	Full	100-pr. 20 lb.	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	3	23	—
		12	-	Reduced and saluting	100-pr. 12 lb.	18	[illegible]	[illegible]	17·4	[illegible]	[illegible]	3	21	—
	10-in.	12	Service*	Full*	10-in. 12 lb.	17	16	13	16	[illegible]	[illegible]	3	3	19
		8	Martin shell,* carcass, saluting, or exercising.	Martin shell, carcass, and reduced.	10-in. 8 lb.	14½	16	13	13½	14	11	3	1	19
	8-in.	10	Service, 65 and 60 cwt. gun	Distant, 65 and 60 cwt. gun.	8-in. 65 or 60 D 10 lb.	19	13½	9½	18	12¾	9½	3	3	17
		8	Service, 52 or 50 cwt. and Martin shell.	Full and Martin shell	8-in. 8 lb.	17	13½	9½	16	12¾	9½	3	2	17
		5	Saluting or exercising	Reduced, with coal-dust wad.	8-in. 5 lb.	15	13½	9½	14	12¾	9½	3	2	17
	68-pr.	18	Service, 112 cwt. gun	-	68-pr. 18 lb.	24	23¼	—	23	11¼	—	3	3	19
		16	Service, 95 cwt. gun	Distant, 95 cwt. gun	68-pr. 16 lb.	23	23¼	—	21	11¼	—	3	3	19
		14	Service, 87 cwt. gun	Distant, 87 cwt. gun	68-pr. 14 lb.	20½	23¼	—	19½	11¼	—	3	3	19
		12	-	Full, 95 cwt. gun	68-pr. 12 lb.	19	23¼	—	18	11¼	—	3	3	19
		10	Martin shell*	Full, 87 cwt. gun, and Martin shell.	68-pr. 10 lb.	17½	23¼	—	16½	11¼	—	3	2	19
		8	Saluting or exercising	Reduced 95 cwt. gun	68-pr. 8 lb.	15½	23¼	—	14½	11¼	—	3	1	19
		6	-	Reduced, 87 cwt. gun	68-pr. 6 lb.	14	23¼	—	13	11¼	—	3	1	19
	56-pr.	14	Service	-	56-pr. 14 lb.	20	22½	—	19	10½	—	3	3	17
		8	Saluting or exercising	-	56-pr. 8 lb.	15	22½	—	14	10½	—	3	2	17
	42-pr.	14	Service, 84 cwt. gun	-	42-pr. 14 lb.	22½	21	—	21½	10	—	3	3	17
		12	Service, 75 cwt. gun	-	42-pr. 12 lb.	20	21	—	19	10	—	3	3	17
		10½	Service, 67 cwt. gun and hot shot, 84 cwt. gun.	-	42-pr. 10½ lb.	18	21	—	17	10	—	3	3	17
		8	Saluting or exercising*	-	42-pr. 8 lb.	16	21	—	15	10	—	3	2	17

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* Where weight of gun is not mentioned that charge is used with all guns of that nature.

† All cannon cartridges, both for smooth-bore and rifled guns, issued from store filled, are to have the initial letter of the station at which they are filled stamped on the bottom end, see p. 154. The cartridges filled by the Royal Artillery will be distinguished by having no initial letter stamped on them. Approved 28th May 1863; War Office Circular No. 835, Stores; Paragraph 785.

‡ Blue braid, about [illegible] inches broad; each loop 40 inches long.

Appendix RRR. Service Charges and Dimensions of Cartridges, 1863, cont'd

Nature of Ordnance.		Charge.	Purpose for which each Charge is intended.		How marked.*	Cartridges.						No. Rows of Stitches.	No. of Hoops.	No. Paper Cover.
						Pattern.			When Sewed.					
						Length.	Width.		Length.	Width.				
			Land Service.	Sea Service.			Top.	Bottm.		Top.	Bottm.			
		lbs.				Inch.	Inch.	Inch.	Inch.	Inch.	Inch.			
Guns—*cont.*	32-pr.	10	Service, 63, 58, and 56 cwt. guns.	Distant, 58 or 56 cwt. guns.	**32-pr. 58 or 56 D 10 lb.**	18	19⅝	—	17	9½	—	3	3	7
		8	Service, 50 to 48 cwt. guns	Full, 58 to 46 cwt. guns	**32-pr. 8 lb.**	16	19½	—	15	9½	—	3	2	7
		7½	Hot shot, 63 to 56 cwt. guns	Hot shot, 58 or 56 cwt. guns.	**32-pr. 7½ lb.**	16	19½	—	15	9½	—	3	2	7
		7	Service, 45 cwt. gun	Full, 45 cwt. gun	**32-pr. 7 lb.**	15	19¼	—	14	9½	—	3	2	7
		6	Service, 46, 42, 41, 40, and 39 cwt. guns.	Reduced, 58 or 56 cwt. guns; full, 42, 41, 40, 39 cwt. guns.	**32-pr. 6 lb.**	14	19⅜	—	13	9½	—	3	2	7
		5	Service, 32 cwt. gun	Reduced, 50, 48, and 45 cwt. guns; full, 32 cwt. gun.	**32-pr. 5 lb.**	13	19½	—	12	9½	—	3	2	7
		4	Saluting or exercising 39 cwt. and upwards. Service, 25 cwt. gun.	Reduced, 42 to 39 cwt. gun; full, 25 cwt. gun.	**32-pr. 4 lb.**	12	19⅜	—	11	9½	—	3	1	7
		3	Saluting or exercising 32 cwt. gun.	Reduced, 32 cwt. gun	**32-pr. 3 lb.**	12	19⅜	—	11	9½	—	3	1	7
		2½	Saluting or exercising 25 cwt. gun.	Reduced, 25 cwt. gun	**32-pr. 2½ lb.**	10¼	19¼	—	9¼	9½	—	3	1	7
		2	- - - - -	Saluting	**32-pr. 2 lb.**	10	19⅝	—	9	9½	—	3	1	7
	24-pr.	8	Service, 50 and 48 cwt. guns	- - - -	**24-pr. 8 lb.**	17¼	17¾	—	16¼	8¾	—	3	3	16
		6	Service, 41 cwt. gun an hot shot, 50 and 48 cwt. gun.	- - - -	**24-pr. 6 lb.**	14¾	17¾	—	13¾	8¾	—	3	2	16
		5	Saluting or exercising 50 and 48 cwt. guns.	- - - -	**24-pr. 5 lb.**	13½	17¾	—	12½	8⅝	—	3	2	16
		4	Service, 33 cwt. gun, saluting or exercising 41 cwt. gun.	- - - -	**24-lb. 4 lb.**	12¾	17¾	—	11¾	8⅝	—	3	2	16
		3	Saluting or exercising 33 cwt. guns.	- - - -	**24-pr. 3 lb.**	11½	17¾	—	10½	8¾	—	3	1	16
		2½	Service, saluting or exercising 20 cwt. guns.	- - - -	**24-pr. 2½ lb.**	10¼	17¾	—	9¼	8¾	—	3	1	16
	18-pr.	6	Service, 42 to 38 cwt. guns	- - - -	**18-pr. 6 lb.**	18	16¼	—	17	7⅞	—	3	3	15
		4½	Hot shot, 42 to 38 cwt. guns	- - - -	**18-pr. 4½ lb.**	15¾	16¼	—	14¾	7¾	—	3	2	15
		4	Saluting or exercising 42 to 38 cwt. guns.	- - - -	**18-pr. 4 lb.**	15	16¼	—	14	7⅞	—	3	2	15
		3	Service, saluting or exercising 22 to 20 cwt. guns.	Full, 22 or 20 cwt. guns	**18-pr. 3 lb.**	13	16¼	—	12	7⅞	—	3	1	15
		2	Service, saluting or exercising 15 cwt. guns.	Reduced, 22 or 20 cwt. guns; full, 15 cwt. gun,	**18-pr. 2 lb.**	11	16¼	—	10	7⅞	—	3	1	15

* All cannon cartridges, both for smooth-bore and rifled guns, issued from store filled, are to have the initial letter of the station at which they are filled stamped on the bottom end, see p. 154. The cartridges filled by the Royal Artillery will be distinguished by having no initial letter stamped on them.—Approved 28th May, 1863; War Office Circular No. 835, stores; Paragraph 763.

Appendix RRR. Service Charges and Dimensions of Cartridges, 1863, cont'd

Nature of Ordnance.		Charge.	Purpose for which each Charge is intended.		Cartridges.									
			Land Service.	Sea Service.	How marked.†	Pattern.			When Sewed.			No. Rows of Stitches.	No. of Hoops.	No. Paper Cover.
						Length.	Width.		Length.	Width.				
							Top.	Bott^m		Top.	Bott^m			
		lbs.				Inch.	Inch.	Inch.	Inch.	Inch.	Inch.			
Guns—*cont.*	12-pr.	4	Service, iron and bronze	- - - -	**12-pr. 4 lb.**	14¾	14¾	—	13¾	6¾	—	3	3	6
		3	Saluting or exercising bronze and 34, 33, 29½ cwt. iron guns.	- - - -	**12-pr. 3 lb.**	12½	14½	—	11¼	6½	—	3	2	6
		2½	Saluting or exercising 21 cwt. iron guns.	- - - -	**12-pr. 2½ lb.**	11¼	14¾	—	10¾	6¾	—	3	2	6
	9-pr.	3	Service iron guns	- - - -	**9-pr. 3 lb.**	13¼	12⅞	—	12½	5¾	—	3	3	13
		2½	Service bronze guns	- - - -	**9-pr. 2½ lb.**	12	12⅞	—	11	5¾	—	3	2	13
		2	Saluting or exercising iron guns.	- - - -	**9-pr. 2 lb.**	10	12⅞	—	11	5¾	—	3	2	13
		1½	Saluting or exercising bronze guns.	- - - -	**9-pr. 1½ lb.**	9	12⅞	—	8	5¾	—	3	1	13
	6-pr.	2	Service iron guns*	- - - -	**6-pr. 2 lb.**	12	11¼	—	11½	5¾	—	2	3	12
		1½	Service, bronze guns, saluting or exercising, iron guns.*	- - - -	**6-pr. 1½ lb.**	10¾	11¼	—	9¾	5¾	—	2	2	12
		1	Saluting or exercising bronze guns.	- - - -	**6-pr. 1 lb.**	8¾	11¼	—	8	5¾	—	2	1	12
		¼	- - - - -	Practice - - -	**6-pr. 4 oz.**	5¼	9	—	4¾	4¼	—	2	—	5
	3-pr.	12oz.	Service, saluting or exercising, bronze 3 cwt. gun.	- - - -	**3-pr. 12 oz.**	8¼	9	—	7¾	4¼	—	2	1	5
		10	Service, saluting or exercising, bronze 2½ cwt. guns.	- - - -	**3-pr. 10 oz.**	7½	9	—	7	4½	—	2	1	5
	1-pr.	6	Service	- - - -	**1-pr. 6 oz.**	8	6¾	—	7	2¾	—	2	1	4
Howitzers,	10-in.	7lb.	Service	- - - -	**10-in. how. 7 lb.**	13¼	11¼	12	12½	10¼	11	3	1	17
		4	Saluting or exercising	- - - -	**10-in. how. 4 lb.**	11½	11¼	12	10¼	10¼	11	3	1	17
	8-in	4	Service	- - - -	**8-in. how. 4 lb.**	13	12	8	12	11	7	3	1	16
		3	Saluting or exercising	- - - -	**8-in. how. 3 lb.**	12¼	12	8	11¼	11	7	3	1	16
	32-pr	3	Service	- - - -	**32-pr. how. 3 lb.**	12¼	14½	—	11¼	6¾	—	3	2	6
		2	Saluting or exercising	- - - -	**32-pr. how. 2 lb.**	10½	14½	—	9½	6½	—	3	1	6
	24-pr.	2½	Service	- - - -	**24-lb. how. 2½ lb.**	11	9¼	7	10	8¼	6	3	1	14
		1½	Saluting or exercising	- - - -	**24-pr. how. 1½ lb.**	9	9¼	7	8	8¼	6	3	1	14
	5½-in.	2	Service, saluting or exercising, 15 cwt. iron.	- - - -	**5½-in. how. 2 lb.**	10¼	13¾	—	9½	6⅝	—	2	1	14

* Where the weight of the gun is not mentioned that charge is used with all guns of that nature.

† All cannon cartridges, both for smooth-bore and rifled guns, issued from store filled, are to have the initial letter of the station at which they are filled stamped on the bottom end, see p. 154. The cartridges filled by the Royal Artillery will be distinguished by having no initial letter stamped on them.—Approved 28th May 1863. War Office Circular No. 835, stores; Paragraph 763.

Appendix RRR. Service Charges and Dimensions of Cartridges, 1863, cont'd

Nature of Ordnance.		Charge.	Purpose for which each Charge is intended.		Cartridges.									
			Land Service.	Sea Service.	How marked.*	Pattern.			When Sewed.			No. Rows of Stitches.	No. of Hoops.	No. Paper Cover.
						Length.	Width. Top.	Width. Bott^m.	Length.	Width. Top.	Width. Bott^m.			
						Inch.	Inch.	Inch.	Inch.	Inch.	Inch.			
Howitzers—*cont.*	12-pr.	2	-	Service, 10 cwt.	12-pr. how. 2 lb.	11½	8	5½	10½	7	4½	2	2	12
		1½	Service 6½ cwt.	-	12-pr. how. 1½ lb.	9½	7½	5½	8½	7	4½	2	1	12
		1	Saluting or exercising 6½ cwt.	-	12-pr. how. 1 lb.	9	7½	5½	8	7	4½	2	1	12
	4⅖-in.	8oz.	Service 2¼ cwt., coehorn	-	4⅖-in. how. 8 oz.	8¼	7¼	—	7¼	3½	—	2	1	4
		4	Saluting or exercising 2¼ cwt., coehorn.	-	4⅖-in. how. 4 oz.	6¼	7¼	—	5½	3½	—	2	1	4
Mortars,	13-in.	20lb.	-	Service	13-in. mor. 20 lb.	25	18	11¼	24	17	10½	3	3	18
		16	-	Carcass	13-in. mor. 16 lb.	21¼	18	11¼	20¼	17	10½	3	3	18
		9	Service	-	13-in. mor 9 lb.	16¼	16½	13	14¼	15¼	12	3	1	19
	10-in.	9½	-	Service	10-in. mor. 9½ lb.	18¼	13	10	17¼	12	9	3	3	17
		4	Service	-	10-in. mor. 4 lb.	13	14	10	*	13	9	3	1	17
	8-in.	2	Service	-	8-in. mor. 2 lb.	10	11	7½	9	10	6½	3	1	14
	5⅗-in.	7oz.	Service, Royal	-	5⅗-in. mor. 7 oz.	7	7¼	6	7¼	6¼	5	2	1	5
	4⅖-in.	5	Service, coehorn	-	4⅖-in. mor. 5 oz.	6	7	5	5¼	6	4	2	1	5
Carronades,	68-pr.	5lb.	-	-	68-pr. carde. 5 lb.	14¼	21	—	13¼	10	—	3	2	—
	42-pr.	3½	-	-	42-pr. carde. 3½ lb.	12¼	19	—	11¼	9	—	3	2	—
	32-pr.	2¾	-	-	32-pr. carde. 2¾ lb.	12¼	17¼	—	11¼	8½	—	3	2	—
	24-pr.	2	-	-	24-pr. carde. 2 lb.	11	16	—	10	7½	—	3	2	—
	18-pr.	1½	-	-	18-pr. carde. 1½ lb.	10¼	13¾	—	9¼	6¼	—	3	2	—
	12-pr.	1	-	-	12-pr. carde. 1 lb.	9	13¼	—	8	6¼	—	3	2	—
	6-pr.	10oz.	-	-	6-pr. carde. 10 oz.	7	10¼	—	6	4¼	—	2	2	—

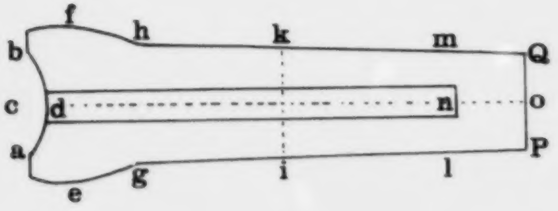
* All cannon cartridges, both for smooth-bore and rifled guns, issued from store filled, are to have the initial letter of the station at which they are filled stamped on the bottom end, see p.184. The cartridges filled by the Royal Artillery will be distinguished by having no initial letter stamped on them.—Approved 28th May 1863; War Office Circular No. 833, stores; Paragraph 702.

Appendix SSS. Dimensions of Common Fuzes, 1752-1830.

Calibre (inches)	Diameters	13 in.	10 in.	8 in.	5 1/2 in.	4 2/5 in.
Diameter of the cup, ab	3	1.575	1.35	1.125	0.825	0.75
Depth of the cup, cd	1 1/2	0.7875	0.675	0.5625	0.4125	0.375
Greatest diameter of fuze, ef	4 3/4	2.494	2.137	1.781	1.306	1.187
Exterior diameter 1 cal. below the top of bore, gh	4	2.1	1.8	1.5	1.1	1.0
Diameter at the middle of the bore Ik	3 1/3	1.75	1.475	1.25	0.917	0.833
Diameter at the bottom of the bore, lm	3	1.575	1.35	1.125	0.825	0.75
Diameter at the bottom of the fuze, pq*	3	1.575	1.35	1.125	0.825	0.75
Thickness of wood at the bottom of the bore, no	2	1.05	0.9	0.75	0.55	0.5
Diameter of the bore	1	0.525	0.45	0.375	0.275	0.25
Length of the bore, dn		8.4	7.2	6.375	4.4	3.5
Length of the bore in calibres		16	16	17	16	14
Outside length of the fuze, co		10.237	8.775	7.6875	5.3625	4.375
Outside length of the fuze in calibres		19 1/2	19 1/2	20 1/2	19 1/2	17 1/2

* In Glegg and Adye this row of dimensions is left empty.

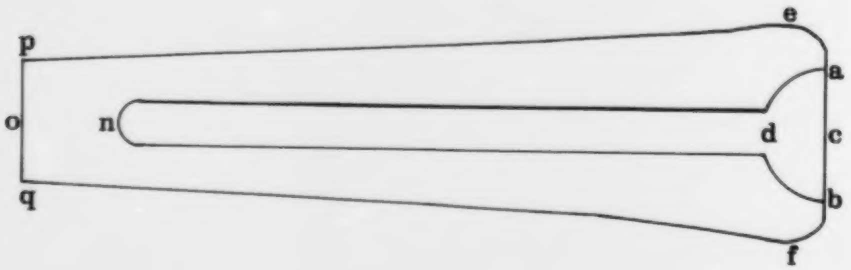
RAI, Glegg, op. cit., p. 12; RAI, Adye (1766), p. 122; RAI, Walton, op. cit., unpaginated; RAI, Meridith, op. cit., p. 18; RAI, Laboratory Notes, circa 1798, unpaginated; Adye (1801), op. cit., pp. 104-5 and (1813), op. cit., p. 128 and (1827), op. cit., p. 173; Spearman (1828), op. cit., p. 224.



Appendix TTT. Dimensions of Common Fuzes, 1830–50

Calibre (inches)	13 in.	10 in.	8 in.	5 1/2 in.	4 2/5 in.
Diameter of the cup, ab	1.49	1.28	1.07	.78	.71
Depth of the cup, cd	.75	.7	.56	.43	.41
Greatest diameter of fuze, ef	2.48	2.14	1.79	1.3	1.18
Diameter at the bottom of the fuze, pq	1.66	1.4	1.16	.9	.82
Thickness of wood at bottom, no	1.25	1.13	.85	.65	.62
Diameter of the bore	.525	.45	.375	.275	.25
Length of the bore, dn	8.5	7.47	6.59	4.49	3.5
Outside length of fuze, co	10.55	9.3	8.	5.6	4.6

RAI, Denning Papers, "Laboratory Course," p. 10.



Appendix UUU. Round Fuze Gauge made of Steel, 1752

Nature	a b in.	b c in.	c d in.	d e in.	a k in.	e f in.
13 in.	8.4	1.05	0.7875	0.7875	0.525	0.55
10	7.2	.9	0.675	0.675	0.45	0.475
8	6.375	.75	0.5625	0.5625	0.375	0.4
5 1/2	4.4	.55	0.4125	0.4125	0.275	0.3
4 2/5	3.5	.5	0.375	0.375	0.25	0.275

ab - length of the bore
bc - thickness of wood left at the bottom
ce - diameter of the cup
ak - diameter of the bore
ef - if that goes into the fuze the bore is too big and should not be received
ad - whole length of fuze

Source: RAI, Glegg, Notes on Artillery, circa 1752, p. 10; RAI, Walton, "Gunnery Tables 1780-1792...," unpaginated; RAI, Meridith, Laboratory Notes, 1780, p. 19; RAI, Frazer, "Work Notes," p. 11.

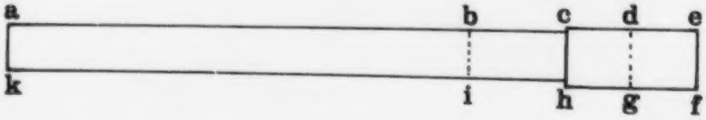
Variation of the above, circa 1798

	a b in.	b c in.	c d in.	a k in.	e f in.
13 in.	8.4	0.7875	1.05	0.525	0.55
10	7.2	0.675	0.9	0.45	0.475
8	6.375	0.5625	0.75	0.375	0.4
5 1/2	4.4	0.412	0.55	0.275	0.3
4 2/5	3.5	0.375	0.5	0.25	0.275

ab - the length of the bore
bc - the depth of the cup
cd - thickness of wood left at the bottom
ak - diameter of the bore and must go tight into fuze up to ch
ef - if that goes into the fuze the bore is too big and should not be received
ad - whole length of the fuze

Source: RAI, Laboratory Notebook, circa 1798, unpaginated.

Round Fuze
Gauge
1752



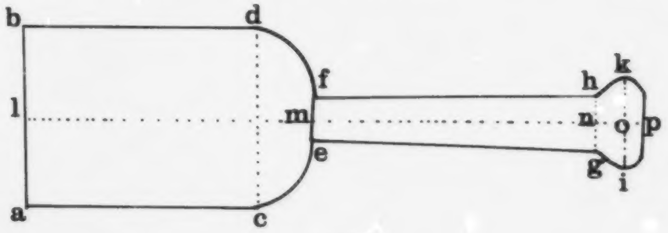
Appendix VVV. Dimensions of Mallets as regulated in 1753

	Diameters					Lengths					Weight	
	ab in.	cd in.	ef in.	gh in.	ik in.	lm in.	mp in.	np in.	op* in.	lp in.	lb.	oz.
For setting 13 inch fuzes	4.06	4.06	1.4	1.4	2.3	8.05	7.15	1.02		15.2	3	8
For driving 13 inch fuzes and setting 10 inch fuzes	3.5	3.5	1.3	1.3	2.0	6.43	6.1	0.87		12.53	2	1
For driving 10 inch fuzes and large long portfires, and setting 8 inch fuzes	3.2	3.2	1.2	1.2	1.85	6.0	6.0	0.85		12.0	1	10
For driving 8 inch fuzes, large short and small long portfires, and setting Royal and Coehorn fuzes	2.95	2.95	1.15	1.15	1.7	5.52	5.9	0.83		11.42	1	4 1/2
For driving Royal fuzes and small short portfires	2.55	2.55	1.12	1.12	1.68	4.68	5.15	0.727		9.83		14
For driving Coehorn fuzes	2.2	2.2	1.1	1.1	1.65	4.46	5.0	0.725		9.46		11
For driving Musquet Mortars and hand fuzes	2.0	2.0	1.0	1.0	1.5	4.12	4.98	0.701		9.1		8 1/2

*In all cases op is 1/3 of np.

RAI, Glegg, op. cit., p. 6; RAI, Adye (1766), op. cit., pp. 125-6, 147; RAI, Walton, op. cit., unpaginated; RAI, Meridith, op. cit., p. 20; RAI, Laboratory Notes, circa 1798, unpaginated; RAI, Frazer, "Work Notes," p. 76. There are some minor variations.

Mallets as Regulated in 1753

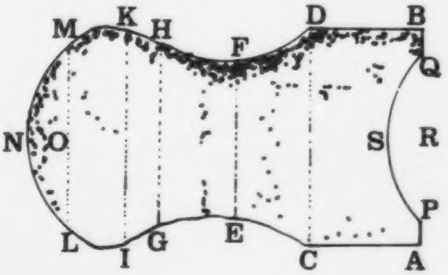


Appendix WWW. Dimensions of Setters for Fuzes, 1750-1800

Calibre	13 in.	10 in.	8 in.	5 1/2 in.	4 2/5 in.
Heights					
AC	2.7	2.3	1.92	1.42	1.3
CG	4.1	3.5	3.15	3.0	2.6
GL	1.5	1.25	1.0	0.9	0.75
ON	0.6	0.4	0.35	0.3	0.27
NR	8.9	7.45	6.42	5.62	4.92
SR	.47	0.42	0.37	0.27	0.25
Diameters					
AB	3.4	2.95	2.5	1.85	1.75
CD	3.65	3.15	2.65	1.97	1.85
EF	2.7	2.3	1.92	1.42	1.3
GH	3.2	2.8	2.37	1.77	1.67
IK	3.4	2.95	2.5	1.85	1.75
LM	3.2	2.8	2.37	1.77	1.67
AP	0.35	0.32	0.3	0.25	0.22
PQ	2.7	2.3	1.92	1.42	1.3

RAI, Glegg, Notes on Artillery, circa 1752, p. 8; RAI, Adye (1766), pp. 123-4, 147; RAI, Walton, "Gunnery Tables 1780-1792...," unpaginated; RAI, Meridith, "Laboratory Notes, 1780," p. 19; RAI, Laboratory Notes, circa 1798, unpaginated; RAI, Frazer, "Work Notes," p. 83.

Setters for Fuzes 1752



Appendix XXX. Ladles

Nature	Contents oz.	dr.	No. of Strokes per ladle full
13 in.	2	0	21
10	1	0	18
8		8	15
5 1/2		6	13
4 2/5		4	12

RAI, "Artillery Experiments 1770-l; 1773," unpaginated; RAI, Meridith, "Laboratory Notes, 1780," p. 17; RAI, Laboratory Notes, circa 1798, unpaginated; RAI, Frazer, "Work Notes," p. 75; Adye (1813), "Observations on a Course of Instruction in Artillery (1825), p. 189; RMC, Mould, op. cit., p. 24; Spearman (1828), The British Gunner, p. 226 and (1844), op. cit., unpaginated.

Appendix YYY. Quick Match for Fuzes

Nature	Weight of Quick Match dr.	Length of Quick Match in.	No. of Threads pre-1820	No. of Threads post-1820
13 in	8	17	4	6
10	6	14	4 or 3	6
8	4	12	3	5
5 1/2	3	10	2	3
4 2/5	3	8	2	3

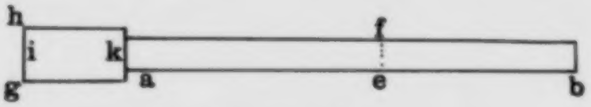
RAI, "Artillery Experiments, 1770-1; 1773," unpaginated; RAI, Laboratory Notes, circa 1798, unpaginated; RAI, Frazer, "Work Notes," p. 75; Adye (1813), p. 188; RMC, Mould, op. cit., p. 25; Spearman (1828), op. cit., p. 224 and (1844), op. cit., unpaginated.

Appendix ZZZ. Dimensions of Drifts (iron, tipped with brass or copper) for driving Fuzes

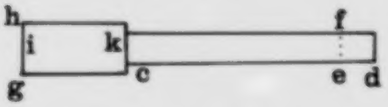
Nature of Drift	No. 1 Length of body ab in.	No. 2 Length of body cd in.	Diameter of body ef in.	Diameter of handle gh in.	Length of handle ik in.
13 in.	9.6	4.889	0.5	0.9	1.7
10	8.2	4.125	0.438	0.75	1.6
8	7.15	3.15	0.375	0.7	1.5
5 1/2	4.875	2.85	0.275	0.55	1.37
4 2/5	4.0	2.2	0.25	0.46	0.95

RAI, Walton, op. cit., unpaginated; RAI, Laboratory Notes, circa 1798, unpaginated; RMC, Mould, op. cit., p. 24; Spearman (1828), op. cit., p. 226 and (1844), op. cit., unpaginated. There are minor variations in some of these sources.

No. 1



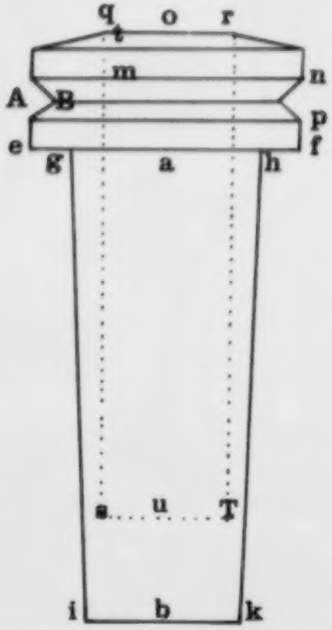
No. 2



Appendix AAAA. Dimensions of Brass Sockets for Driving Fuzes, circa 1780

Calibre	Exterior Dimensions									Interior Dimensions					
	The Body				The Head										
in.	ab in.	as* in.	gh in.	ik in.	ef in.	pf in.	Qt in.	tm in.	np in.	Qr in.	ST in.	ub in.	uo in.	bo in.	AB in.
13	8.125	1.175	2.4	2.075	3.25	0.4	0.2	0.35	0.175	2.1	1.875	0.75	8.75	9.5	0.15
10	6.850	0.875	2.0	1.85	2.525	0.3	0.1	0.25	0.2	1.84	1.6	0.4	7.375	7.775	0.15
8	5.5	0.76	1.75	1.75	2.35	0.2	0.1	0.3	0.16	1.525	1.3	0.57	5.78	6.35	0.15
5 1/2	3.9	0.8	1.45	1.45	2.0	0.2	0.125	0.225	0.2	1.1	0.975	0.45	4.3	4.75	0.15
4 2/5	3.25	0.85	1.34	1.15	1.975	0.2	0.1	0.2	0.28	1.0	0.925	0.725	3.375	4.1	0.15

* It is not clear of what this measurement is.
RAI, Walton, "Gunnery Tables 1780-1792," unpaginated.



Appendix BBBB. Method of Making QuickMatch, circa 1800

To make Cotton Quickmatch

	lb.	oz.	
Cotton	1	12	
Salt Petre	1	8	
Spirits of Wine			4 pints
Water			5 pints
Mealed Powder	10	0	

Take Cotton either two, three or four threads according to the Size wanted to be made and unwind it into a Copper Pan fastening the outward end to the handle of the Pan let the Petre be under the Cotton, then pour over the Water and let it boil about an hour, then pour in the Spirits of Wine and let it simmer about a quarter of an hour, then take it off into another Room and put about six pounds of mealed powder over it or as much as will cover it well and let it be well soaked; then untie and take the end fastened to the handle and draw the Cotton gently through your fingers into another Pan fastening the last end to the handle of the second Pan, pour the liquor which is left in the first Pan over the Cotton in the second Pan, and let it stand some small time as before, then fasten the end to the Reel and reel it off, this requires two men, one to sit down and let the Cotton slide gently through his fingers not pressing it too hard for fear of breaking, while the other man keeps turning the Reel round moderately till it is filled with the Cotton, when full break off the end and tie it to one side of the Reel observing to fill each Reel in the same manner, but only one at a time.

One Reel being fill'd put two battins on the table and lay the quickmatched Reel upon them, then sift mealed Powder all over the upper side of the quickmatch missing not the least Part, then turn the Reel and sift equally over the Match as before sifting it well over both sides, and looking well all over it now and then to see that no part shines, wherever the Match appears shining it is missed, and such Places must be sifted over till the whole is well covered. Next set up the Reel edgeways giving it a gentle knock or two upon the table to shake off the superfluous loose powder, then lift the Reel carefully off the Table and set it upon the Floor letting it lean edgeways agains the Wall to dry; proceeding in like manner to sift over both sides of every Reel as fast as they are compleated with quickmatch setting the reels leaning one against the other to dry till the whole is compleatly reeled off and sifted and shifting the Reels every other Day.

After sifting each Reel the loose Powder which falls on the Table must be swept together with a hand Brush to be taken up with a copper Shovel and put into the Sieve to serve in part for sifting over the next Reel.

In Summer about ten days will be sufficient for the match to dry in, after which it may be cut off, tied up in Bundles and hung upon Pins or laid carefully in fir Boxes with sliding covers — Each Bundle of Quickmatch must be weighed off, tied up in paper, and ticketed with the weight before they are put up into Boxes.

The weight of each Bundle of Quickmatch to be afterwards entered in the Books where Issued for Service.

Source: RAI, Laboratory Notes, circa 1798, unpaginated.

Appendix CCCC. Table of Utensils for Driving Portfires, *circa* 1800 and 1849

	1800 in.	1849 in.
Iron Formers		
Length of body	20.0	20.0
Diameter of body	.43	.45
Length of handle		4.0
Diameter of handle		.71
Length of Case (unfinished)	19.5	
Moulds		
Diameter		
Bottom	4.0	2.2
Top		2.0
Interior	0.64	.7
Length		
Interior	17.65	16.0
Exterior		18.0
Thickness of bottom	2.8	
Socket		
Diameter		
Interior		2.25
Exterior		4.0
Length		
Interior		1.4
Exterior		3.0
Drifts		
Diameter	0.4	0.425
Length, exclusive of handle		
No. 1	17.9	17.8
2	12.55	12.6
3	7.55	7.5
4	4.25	4.2
Handle		1.4
Nature of Mallet	for 8-in. fuze	1 lb. 10 oz.
Nature of Copper Ladle	2 oz.	for 10-in. fuze
No. of Blows per Ladle Fall	15	15

Based on RAI, Frazer, "Work Notes," p. 65 and RMC, Noble, "Notes on Practical Artillery" (1849), pp. 292, 294.

Appendix DDDD. Dimensions (in inches) of Tin Tubes

Length of tube (without cup)	April 1755[1]	1766[2]	1779[3]	1801[4]
Heavy Guns				
42 pdr.		9 3/4	9.7	
32		9 1/2	9.7	
24	8.8	8 1/2	8.9	8.8
18	8.2	8	8.0	8.2
12	7.75	7 3/10	7.3	7.75
9	6.8	6 8/10	6.8	6.8
6	6.5	6 1/2	6.5	6.5
4			6.5	
3	5.9	5 9/10	5.9	5.9
1 1/2	4.75	4 3/4	4.2	4.75
Medium Guns				
24 pdr.	8.8	8 1/2	8.3	8.8
18				8.2
12	7.75	7 3/10	7.3	7.75
9			6.8	6.8
6	5.9	5 9/10	5.7	5.9
4			5.7	
3				
1 1/2				4.75
Light Guns				
24	6.5	6 1/2	6.5	6.5
12	5.9	5 9/10	5.7	5.9
6	4.75	4 3/4	4.7	4.75
4			4.7	
3		4 3/10	4.2	
Howitzers				
8-in.	6.5	6 1/2	6.5	6.5
Royal	5.9	5 9/10	5.7	5.9
Coehorn	4.2	3 6/10	4.2	4.2
Land Service Mortars				
13-in.	7.75	7 8/10		7.75
10	5.9	5 9/10	5.7	6.5
8	5.0	5	4.7	5.0
Royal	4.2	4 2/10	4.2	4.2
Coehorn	3.6	3 6/10	3.6	3.6
Sea Service Mortars				
13-in.	12.0	12	12.0	12.2
10	7.75	7 1/2	7.75	7.75

Appendix DDDD. Notes

1 RAI, Meridith, "Laboratory Notes, 1780," p. 27, "Dimensions of Tin Tubes April 1755."
2 RAI, Adye (1766), pp. 119-20.
3 Smith, An Universal Military Dictionary..., p. 248. Slightly modified and corrected.
4 Adye (1801), p. 209 and (1813), p. 382.

Meridith gave the exterior diameter of the tube, 0.15 in. and the exterior diameter of the cup, 0.9 in. Smith said the tube was 0.2 in. in diameter, but that was also the vent diameter. He agreed with the cup diameter except

13-in. S.S. Mortar	1.2
10-in. L.S. and S.S. mortars	1.0
5 1/2-in. mortar	.8
all Howitzers	.8

Appendix EEEE. Richardson's Description of the 18 Foot Triangle Gyn, New Pattern

It consists of two Cheeks, a Prypole and a Windlass. The top of the gyn is connected by means of a bolt to which the Shackle is attached. The Windlass consists of a cylindrical piece of wood with an axle at either end fitting into corresponding holes in the Cheeks and kept in position by means of two iron cross bars, the two ends of which revolve on bolts in the cheeks their other ends being keyed up on the opposite cheeks. On either end of the windlass are two arrangements of teeth with their points fixed in contrary directions. The use of one pair of these is to prevent the windlass revolving backwards, effected by means of two iron palls attached to the Cheeks which can be fixed in position or not at pleasure. In working the gyn, the windlass being kept firm by means of the palls, there are two other sets of teeth one under each Lever socket to which are attached pinions to catch the teeth and to enable the levers [heavers?] to heave on the windlass downwards and at the same time to allow of their returning back and taking another purchase without the former operation of 'fetching and heaving.'

Source: RAI, J.B.S. Richardson, Account of Long Course at Shoeburyness, 1859-60. Bound MS, unpaginated.

Appendix FFFF. Inventory of Original Pieces of Smooth-bore Ordnance at Environment Canada's National Historic Parks and Sites

Calibre	Length ft.	Length in.	Weight cwt.	Weight qr.	Weight lb.	Date of Manufacture	Manufacturer	Location
Guns, Brass								
3-pdr.	4		3	0	1	1799	J. & H. King	Carleton Martello Tower, Saint John, N.B.
	4					1800	J. & H. King	Carleton Martello Tower, Saint John, N.B.
	4		3	0	7	1810	J. & H. King	Lower Fort Garry, Man.
	4		3	0	1	1807	J. & H. King	Lower Fort Garry, Man.
	4		3	0	6	1810	J. & H. King	Lower Fort Garry, Man.
	4		3	0	3	1809	J. & H. King	Lower Fort Garry, Man.
	3		2	0	14	1812	F. Kinman	Lower Fort Garry, Man.
	3							Fort Wellington, Prescott, Ont.
6-pdr.	5		6	0	9	1813	J. & H. King	Fort Beauséjour, N.B.
	5		6	?	1	1797	J. & H. King	Lower Fort Garry, Man.
Guns, Iron								
1/2-pdr.	2	6	1	1	1			Fort Langley, B.C.
	2	6						Lower Fort Garry, Man.
	2	6						Lower Fort Garry, Man.
	2							Fort Beauséjour, N.B.
	1	10				1760-1820		Fort Wellington, Prescott, Ont.
	1	10				1760-1820		Fort Wellington, Prescott, Ont.
1-pdr.	3	10						Fort Anne, N.S.
	2	6						Fort Beauséjour, N.B.
2-pdr.	3	2	2	3	25		B.P. & Co.	St. Andrews Blockhouse, St. Andrews, N.B.
	3	3	2	3	25		B.P. & Co.	Fort Lennox, Quebec
3-pdr.	6					circa 1710		Fort George, Ont.
	5		4	3	8			Lower Fort Garry, Man.
	3	6					S. Co.	Lower Fort Garry, Man.
	3	6					S. Co.	Lower Fort Garry, Man.
	3	6					S. Co.	Lower Fort Garry, Man.
4-pdr.	4	6						Fort Anne, N.S.
	4	6						Fort Edward, N.S.
6-pdr.	9		24	0	0	1714-27		Fort Prince of Wales, Man.
	9		23	3	0	1714-27		Fort Prince of Wales, Man.
	8	6	22	2	7	circa 1710		Fort Prince of Wales, Man.
	8	6	21	2	21	circa 1710		Fort Prince of Wales, Man.
	8	6	22	1	0	circa 1710		Fort Prince of Wales, Man.
	8	6	22	0	21	circa 1710		Fort Prince of Wales, Man.
	8	6	22	0	11	circa 1710		Fort Prince of Wales, Man.
	8	6	22	0	7	circa 1710		Fort Prince of Wales, Man.
	5	6				circa 1710		Fort George, Ont.
9-pdr.	8	6	25	3	0	1702-14		Castle Hill, Nfld.
	8	6	26	2	2	1702-14		Castle Hill, Nfld.
	6	6				1760-90		York Redoubt, Halifax, N.S.
	6	4				1800-20		Fort Amherst, P.E.I.
	6	4				1800-20		Fort Amherst, P.E.I.
	6	4				1800-20		Fort Amherst, P.E.I.

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Calibre	Length ft.	in.	Weight cwt.	qr.	lb.	Date of Manufacture	Manufacturer	Location
Guns, Iron (cont'd)								
12-pdr.	9		32	1	3	1702-14		Fort Prince of Wales, Man.
	9		33	0	5	1702-14		Fort Prince of Wales, Man.
	9		33	1	3	1702-14		Fort Prince of Wales, Man.
	9		32	0	1	1702-14		Fort Prince of Wales, Man.
	9		33	1	17	1702-14		Fort Prince of Wales, Man.
	9		32	2	17	1702-14		Fort Prince of Wales, Man.
	9		33	0	14	circa 1710		Churchill, Man.
	9		32	1	0	circa 1710		Fort Prince of Wales, Man.
	9		33	1	17	circa 1710		Fort Prince of Wales, Man.
	9		33	2	4	circa 1710		Fort Prince of Wales, Man.
	9		33	2	4	circa 1710		Fort Prince of Wales, Man.
	9		33	1	18	circa 1710		Fort Prince of Wales, Man.
	9		33	1	0	circa 1710		Fort Prince of Wales, Man.
	9		33	1	11	circa 1710		Fort Prince of Wales, Man.
	9		33	0	14	1714-27		Fort Prince of Wales, Man.
	9		33	0	0	1714-27		Fort Prince of Wales, Man.
	9		33	1	21	1714-27		Fort Prince of Wales, Man.
	9		33	0	21	1714-27		Fort Prince of Wales, Man.
	9		33	0	17	1714-27		Fort Prince of Wales, Man.
	9		33	1	14	1714-27		Fort Prince of Wales, Man.
	9		35	1	0	1714-27		Fort Prince of Wales, Man.
	9		33	2	0	1714-27		Fort Prince of Wales, Man.
	9		33	2	21	1714-27		Fort Prince of Wales, Man.
	8		33	0	24	1714-27		Fort Prince of Wales, Man.
	8	6	29	3	1	circa 1780		York Redoubt, Halifax, N.S.
	9		33	?	25	1819?	Carron	Citadel, Halifax, N.S.
	8	6	32	2	24	1800-20	Walker	Citadel, Halifax, N.S.
	8	6	32	3	7	1800-20	Walker	Citadel, Halifax, N.S.
	8	6	32	3	27	1800-20	Walker	Citadel, Halifax, N.S.
	8	6	33	3	17	1800-20	Walker	Castle Hill, Nfld.
	7	6	29	0	22	circa 1780		York Redoubt, Halifax, N.S.
18-pdr.	9					1727-60		Gut of Digby, N.S.
	9		41	2	10	1727-60		Gut of Digby, N.S.
	9					1727-60		Gut of Digby, N.S.
	9					1760-80		St. Andrews Blockhouse, St. Andrews, N.B.
	9		41	1	24	1760-80		St. Andrews Blockhouse, St. Andrews, N.B.
	9		40	2	7	1760-80		St. Andrews Blockhouse, St. Andrews, N.B.
	9		4?	9	0	1760-80		Fort Beauséjour, N.B.
	9		41	1	21	1760-80		Fort Beauséjour, N.B.
	9					1760-80		Fort Beauséjour, N.B.
	9		41	2	21	1760-80		Fort Anne, N.S.
	9		41	2	14	1760-80		Fort Anne, N.S.
	9		42	0	0	1760-80		Fort Anne, N.S.
	8					1800-20		York Redoubt, Halifax, N.S.
	8					1800-20		York Redoubt, Halifax, N.S.
	8					1800-20		Fort Lennox, Quebec
	7	6				1800-20		York Redoubt, Halifax, N.S.

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Calibre	Length ft.	Length in.	Weight cwt.	Weight qr.	Weight lb.	Date of Manufacture	Manufacturer	Location
Guns, Iron (cont'd)								
18-pdr.(cont)	8					1800-20		York Redoubt, Halifax, N.S.
	8					1800-20		York Redoubt, Halifax, N.S.
	8		38	0	16	1800-20	Walker	Fort George, Ont.
	9		42	1	4	1800-20		York Redoubt, Halifax, N.S.
	9		42	0	7	1800-20	Walker	rue des Remparts, Québec
	9		41	3	5	1800-20	Walker	rue des Remparts, Québec
	9		41	3	?	1800-20	Walker	rue des Remparts, Québec
	9		41	3	12	1800-20	Walker	rue des Remparts, Québec
	9		41	3	11	1800-20	Walker	rue des Remparts, Québec
	9		42	0	19	1800-20	Walker	rue des Remparts, Québec
	9		41	3	12	1800-20	Walker	rue des Remparts, Québec
	9	6	49	3	26	1714-27		Fort Prince of Wales, Man.
	9	6	48	0	21	1714-27		Fort Prince of Wales, Man.
	9	6	48	1	21	1714-27		Fort Prince of Wales, Man.
	9	6	48	2	0	1714-27		Fort Prince of Wales, Man.
	9	6	49	3	14	1714-27		Fort Prince of Wales, Man.
	9	6	49	3	21	1714-27		Fort Prince of Wales, Man.
	9	6	?	?	24	1714-27		Fort Prince of Wales, Man.
	9	6	49	3	21	1714-27		Fort Prince of Wales, Man.
	9	6	49	3	21	1714-27		Fort Prince of Wales, Man.
	9	6	48	1	14	1714-27		Foret Prince of Wales, Man.
	9	6	50	0	14	1800-20	Walker	Town Hall, St. Andrews, N.B.
	9	6	50	0	14	1800-20	Walker	Town Hall, St. Andrews, N.B.
	9	6	50	0	21	1800-20	Walker	Fort Beausejour, N.B.
	9	6				1800-20		York Redoubt, Halifax, N.S.
	9	6	51	2	14	1807	Carron	Fort Wellington, Prescott, Ont.
	9	6	49	3	7	1800-20	Walker	Fort Wellington, Prescott, Ont.
24-pdr.	9	6	50	1	21	1812	Carron	rue des Remparts, Québec
	9	6	51	2	0	1807	Carron	rue des Remparts, Québec
	9	6				1807	Carron	Fort George, Ont.
	9	6				1807	Carron	Fort George, Ont.
	9		48	0	6	1800-20	Walker	rue des Remparts, Québec
	9		47	3	4	1800-20	Walker	rue des Remparts, Québec
32-pdr.	9	6	56	2	21	1800-20	Walker	rue des Remparts, Québec
	9	6	55	2	21	1800-20	Walker	rue des Remparts, Québec
	9	6	55	3	7	1800-20	Walker	rue des Remparts, Québec
	9	6	56	0	25	1807	Carron	rue des Remparts, Québec
	9	6	56	1	7	1806	Carron	rue des Remparts, Québec
	9	6	55	2	21	1800-20	Walker	rue des Remparts, Québec
	9	6	56	1	11	1806	Carron	rue des Remparts, Québec
	9	6	55	2	21	1800-20	Walker	rue des Remparts, Québec
	9	6	56	3	25	1807	Carron	rue des Remparts, Québec
	9	6	56	2	14	1807	Carron	rue des Remparts, Québec
	9	6	55	3	14	1806	Carron	rue des Remparts, Québec
	9	6	56	1	21	1806	Carron	rue des Remparts, Québec
	9	6	56	2	21	1806	Carron	rue des Remparts, Québec
	9	6	55	0	21	1800-20	Walker	rue des Remparts, Québec

Appendix FFFF. Inventory of Original Pieces of Smooth-bore Ordnance at Environment Canada's National Historic Parks and Sites

Calibre	Length ft.	Length in.	Weight cwt.	Weight qr.	Weight lb.	Date of Manufacture	Manufacturer	Location
Guns, Iron (cont'd)								
32-pdr.(cont)	9	6	55	2	10	1800-20	Walker	rue des Remparts, Québec
	9	6	56	1	1	1806	Carron	rue des Remparts, Québec
	9	6	56	0	10	1806	Carron	rue des Remparts, Québec
	9	6	56	0	0	1806	Carron	rue des Remparts, Québec
	9	6	55	1	14	1806	Carron	rue des Remparts, Québec
	9	6	55	3	7	1800-20	Walker	rue des Remparts, Québec
	9	6	55	2	25	1800-20	Walker	rue des Remparts, Québec
	9	6	55	1	17	1800-20	Walker	rue des Remparts, Québec
	9	6	55	1	21	1800-20	Walker	rue des Remparts, Québec
	9	6				1807	Carron	Dufferin Terrace, Québec
	9	6				1806	Carron	Dufferin Terrace, Québec
	9	6	?	?	7	1800-20	Walker	Dufferin Terrace, Québec
	9	6				1800-20	Walker	Dufferin Terrace, Québec
68-pdr.	10		95	1	0	1858		Citadel, Halifax, N.S.
Carronades								
12-pdr.	2	8.75						Fort Anne, N.S.
24-pdr.	3	8						York Redoubt, Halifax, N.S.
	3	7.75						York Redoubt, Halifax, N.S.
32-pdr.	4		17	3	0			Fort Wellington, Prescott, Ont.
	4		17	0	9			Fort Wellington, Prescott, Ont.
Carronades, with trunnions								
4-pdr.	3							Fort Beauséjour, N.B.
6-pdr.	3	1.5						Fort Anne, N.S.
	3	1.5						Fort Wellington, Prescott, Ont.
	3	6						Lower Fort Garry, Man.
18-pdr.	3	4	7	3	18			Fort George, Ont.
	3	3	8	1	?			Fort George, Ont.
Mortars, Brass								
Coehorn	1	1				1827-60		Coteau du lac, Québec
Royal	1	2	1	1	14	1760-1820		Fort Lennox, Québec
						1800	F. Kinman	Fort Wellington, Prescott, Ont.
Mortars, Iron								
8-inch	2	2.5						Fort Beauséjour, N.B.
10-inch	4	7	47	2	14	1798	Carron	rue des Remparts, Québec
	4	7	47	3	4	1798	Carron	rue des Remparts, Québec
	3	10	52	0	13	1813	Carron	rue des Remparts, Québec
	3	10	52	1	8	1855	Walker	rue des Remparts, Québec
Howitzers, Iron								
24-pdr.	3	5	15	1	11	Circa 1830?		Fort George, Ont.

Note: There are some weapons stored near Signal Hill National Historic Park, St. John's, Newfoundland, which are not included in this inventory because of the lack of reliable information.

ENDNOTES

The Manufacturing of Ordnance

1 Captain Manley Dixon, "Remarks on Military Carriages and Gun Metal," Minutes of Proceedings of the Royal Artillery Institution, Vol. 1 (1858), p. 105.

2 Royal Engineers, Aide-Mémoire to the Military Sciences [Henceforth Aide-Memoire] (London: John Weale, 1850), Vol. 2, p. 523. At different times different proportions were given: Captain George Smith, An Universal Military Dictionary (London: J. Millan, 1779; reprinted, Ottawa: Museum Restoration Service, 1969), p. 175, specified 100 lbs. of copper to 12 lbs. of tin; Ralph Willett Adye, The Bombardier and Pocket Gunner, Revised and corrected by William Granville Eliot (London: T. Egerton, 1813), p. 218, and F.A. Griffiths, The Artillerists's Manual and British Soldier's Compendium (Woolwich: E. Jones, 1847), p. 58, indicated 100 lbs. of copper to 8 or 10 lbs. of tin.

3 Woolwich. Royal Artillery Institution Library [Henceforth RAI], Casting and Proving of Ordnance, MS notebook, late eighteenth century, unpaginated.

4 Ibid.

5 H.L. Blackmore, The Armouries of the Tower of London: I: Ordnance (London: Her Majesty's Stationery Office, 1976), pp. 407-9.

6 Aide-Mémoire, op. cit., Vol. 2, p. 523; Royal Military College. Massey Library, Henceforth RMC , E.M. Lloyd, Notes on Artillery, 1859, pp. 124-7; Dixon, op. cit., pp. 105-6.

7 Melvin H. Jackson and Carel de Beer, Eighteenth Century Gunfounding: The Verbruggens at the Royal Brass Foundry, A Chapter in the History of Technology (Washington: Smithsonian Institution Press, 1974).

8 Dictionary of National Biography [Henceforth DNB], Vol. 32, p. 52.

9 RAI, Isaac Landmann, "Gun Factory Notes," Vol. I (1793), Vol. 2 (1795). The second volume bears the title "Petit traité practique sur la maniere [sic] de fondre et de mouler les canons et les mortiers" with the attribution "Par I. Landmann 1795." Both volumes are written in French, which was Landmann's mother tongue. The processes described have been summarized by Adrian B. Caruana, "British Production of Brass Ordnance, 1780," The Canadian Journal: Arms Collecting, Vol. 16, No. 4 (1978), pp. 107-18. Caruana acknowledges the uses of "a manuscript in the collection of the RAI , which was prepared by Isaac Landman [sic], Professor of Fortification at the R.M.A. about 1780." Similarity in detail, especially of the drawings reproduced, seems to indicate that he is referring to the above-mentioned manuscripts, but why he attaches the date of 1780 to them is unclear.

10 The secondary literature on the technology of boring is confusing. Jackson and de Beer in their study of the Verbruggens emphasize that the Maritz system "...was based on the development of two factors: massive castings and accurate boring machinery." They seem to imply that Maritz was the first to cast solid. They are explicit, however, that Maritz was the first to rotate the gun and to perform the boring in a horizontal position. Both ffoulkes and Straker assign 1713 not 1715 as the date of the introduction of the new system, and Hughes says 1739. ffoulkes also contends that Maritz invented a machine in which the piece was lowered unto a vertical rotating drill similar to the machine illustrated in Diderot's Encyclopédie, and that Jan Verbruggen, with the help of his colleague Ziegler, developed the horizontal mill at The Hague in 1755. The article "Alésoir" in the Encyclopédie describes a vertical drilling machine and claims that it was invented in Strasbourg and kept secret for a long time, but

that one was now on display at the Paris arsenal. This reference would seem to refer to Maritz and his invention, but there is no reference to horizontal boring, a rather remarkable omission in a work such as the Encyclopédie. Straker claims that in 1740 John Fuller in Sussex "...used a horizontal boring machine, in which the gun was revolved by the waterwheel, and the drill, supported between slide-rails, was gradually advanced by means of a chain wound round a form of windlass." I have followed Jackson and de Beer in this matter since their's is the most recent scholarship on the subject. Jackson and de Beer, op. cit., pp. 16, 73-4; Charles ffoulkes, The Gun-Founders of England (London: Arms and Armour Press, 1969, reprint of 1936 edition), pp. 17-18; Ernest Straker, Wealden Iron (Newton Abbot, Devon: David and Charles, 1969, reprint of 1931 edition), pp. 157-8; B.P. Hughes, British Smooth-Bore Artillery: The Muzzle Loading Artillery of the 18th and 19th Centuries (London: Arms and Armour Press, 1969), p. 26; Denis Diderot, Encyclopédie ou Dictonnaire Raissoné des Sciences des Arts et des Métiers, par une societé de gens de lettres (Paris, 1751-1780), Texte, "Alésoir," pp. 254-5; Planches, "Fonderie des Canons," Vol. 5, plate XVII.

11 Jackson and de Beer, op. cit., pp. 71-4.

12 Ibid., passim, for the careers of Jan and Pieter Verbruggen.

13 Ibid., pp. 49-52; Thomas Southcliffe Ashton, Iron and Steel in the Industrial Revolution (Manchester: Manchester University Press, 1963), pp. 44-6, 63, 68.

14 RMC, A. Noble, "Notes on Practical Artillery," 1849, p. 117.

15 RAI, Landmann, "Gun Factory Notes," op. cit., Vol. I, pp. 2-3; Jackson and de Beer, op. cit., p. 80; RMC, T.R. Mould, "Observations on a Course of Instruction in Artillery," 1825, p. 111.

16 Jackson and de Beer say that the lye mixture was applied after the mould was annealed; Landmann says before. The Verbruggen drawings show the annealing being done on the surface while Landmann and subsequent sources indicate that it was done in the pit. The details are probably not important; the purpose is clear enough. Jackson and de Beer, op. cit., pp. 97-8; RAI, Landmann, "Gun Factory Notes," op. cit., Vol. 2, opposite p. 10.

17 Jackson and de Beer, op. cit., pp. 82, 103; RAI, Landmann, "Gun Factory Notes," op. cit., Vol. 2, p. 13.

18 Jackson and de Beer, op. cit., p. 104; RAI, Landmann, "Gun Factory Notes," op. cit., Vol. 2, pp. 11-12. Later sources agree with Jackson and de Beer, cf. RMC, Mould, op. cit., pp. 109-20; Department of National Defence, Headquarters, Library, [Henceforth DND], H.T. Fitzhugh, A Course of Practical Artillery, 1845, p. 101.

19 Jackson and de Beer, op. cit., p. 96.

20 Ibid., pp. 99-103.

21 Ibid., p. 126, says a loam channel; RAI, Landmann, "Gun Factory Notes," op. cit., Vol. 2, p. 18 and DND, Fitzhugh, op. cit., p. 101, say brick.

22 RAI, Landmann, "Gun Factory Notes," op. cit., Vol. 2, p.23.

23 DND, Fitzhugh, op. cit., p. 102, calls them "pears," presumably alluding to their shape.

24 The process may have been mechanized by the 1820s. Mould says that the dead head was "turned off," a choice of words which suggests that the piece was placed in a lathe and a chisel introduced to remove the deadhead as the gun was turned.

25 "Bouch" and "bouching," equivalent to the modern "bush" and "bushing," are the words used in the contemporary manuals.

26 RAI, Landmann, "Gun Factory Notes," op. cit., Vol. I; Vol. 2, pp. 30-1.

27 Adye (1813), op. cit., pp. 389-90; J. Morton Spearman, The British Gunner

(London: Parker, Furnivall, & Parker, 1844), unpaginated; John F. Owen and Morton Porter, Treatise on the Construction and Manufacture of Ordnance in the British Service (London: Her Majesty's Stationery Office, 1881), p. 60.

28 Owen and Porter, op. cit., p. 60.

29 Ibid., p. 61.

30 RAI, Landmann, "Gun Factory Notes," op. cit., Vol. 1; Vol. 2, pp. 30-1.

31 John Anderson, General Statement of the Past and Present Condition of the Several Manufacturing Branches of the War Department, as called for by a letter dated 8th May 1856 (London: Eyre and Spottiswoode for Her Majesty's Stationery Office, 1857), p. 6.

32 Ibid., p. 6. For a detailed description of the machnery and its working see Aide-Mémoire, op. cit., Vol. 2, pp. 527-38; RMC, Lloyd, op. cit., pp. 143-5; Charles H. Owen, Rough Notes on the Manufacture of Ordnance, Carriages, and Ammunition, prepared for the use of the Gentlemen Cadets of the R.M. Academy (Woolwich: Royal Artillery Institution, 1867), pp. 11-12.

33 Anderson op. cit., p. 7; RMC, Lloyd, op. cit., pp. 130-4; Owen, Rough Notes, op. cit., pp. 9-12.

34 Hughes, British Smooth-Bore Artillery, op. cit., p. 26.

35 Louis de Tousard, American Artillerist's Companion, or Elements of Artillery (Philadelphia: C. and A. Conrad, 1809-14, reprinted, New York: Greenwood Press, 1969).

36 Ibid., pp. 531-46; Aide-Mémoire, (1850), op. cit., Vol. 2, pp. 523-6; RMC, Lloyd, op. cit., pp. 134-7.

37 Maj. Gen. Forbes, History of the Royal Ordnance Services, cited by Colonel A.H. Mockridge, "The Proving of Ordnance and Propellants," The Journal of the Royal Artillery, Vol. 77, No. 1 (1950), p. 88.

38 RAI, Thomas James, "his Book of Artillery &c at the Office of Ordn.ce in the Tower of London, March the 25th, 1722; RAI, "Practice Book, 1760," "General Borgard's Table of Powder allow'd for Iron and Brass guns."

39 RAI, "General Statement of the Regulations & Practice of the Inspector of Artillery's Dept. in Examining, Proving and Receiving of Iron Ordnance supplied by Contractors for H.M. Service and that of the East India Coy," circa 1785 .

40 Smith, op. cit., p. 211.

41 John Muller, A Treatise of Artillery (London: Millan, 1780; reprinted Bloomfield, Ont.: Museum Restoration Service, 1977), p. 111.

42 RAI, Collected Military Papers, Vol. 2, John Bell, Sergt R.R.A., "Observations on an improved method of proving Guns with Water shewing the advantage it has over the former mode - Also a few Remarks on the Utility of the Water proof with the Method of performing it - Woolwich 2d April 1785."

43 Ibid, It is not clear if the water proof was used for mortars and howitzers. According to Smith, op. cit., p. 212, mirrors were usually the only instruments used to detect flaws in the bores of mortars and howitzers.

44 RAI, "General Statement...," op. cit. This unsigned, undated MS appears to be Blomefield's regulations. It agrees substantially with remarks in an MS article, RAI, H.A. Baker, Late Cast Guns, but unfortunately Baker gives no references.

45 Adye (1801), op. cit., p. 180.

46 RMC, Lloyd, op. cit., pp. 159-68.

Brass Guns

1 RAI, James, op. cit., pp. 22, 27, 29.

2 RAI, Glegg, op. cit., pp. 115-16.

3 Smith. op. cit., p. 285; Aide-Mémoire (1850), op. cit. Vol. 2, p. 514; RAI, Isaac Landmann, "Notes on Artillery," p. 12.

4 RAI, Williamson, "Collections, Proportions & Experiments of Artillery," *circa* 1770, p. 102-3; RAI, Casting Proving Guns, Vol. 2, *circa* 1775, unpaginated; RAI, Thomas Walton, Gunnery Tables, unpaginated; RAI, Artillery Practice, Part I, *circa* 1780, pp. 1-2; Adye; op. cit., (1801), p. 115 and (1813), p. 203.

5 Adye, op. cit. (1813), p. 203.

6 Hughes, *Smooth-Bore*, op. cit., p. 28.

7 RAI, Walton, op. cit., unpaginated.

8 RAI, James, op. cit., pp. 22, 27.

9 RAI, Glegg, op. cit., pp. 115-16.

10 Smith, op. cit., p. 285; *Aide-Mémoire*, (1850), op. cit., Vol. 2, p. 514; RAI, Isaac Landmann, "Notes on Artillery," p. 12; RAI, Walton, op. cit., unpaginated.

11 RAI, Adye, op. cit. (1766), pp. 12-14.

12 RAI, "Artillery Practice & Stores," pp. 1-2; RAI, Walton, op. cit., 1781 unpaginated; Peter Padfield, *Guns at Sea* (London: Hugh Evelyn, 1973), "Gunner's Rule," *circa* 1780, p. 106; RAI, Bogue, op. cit., *circa* 1800, pp. 141-2; Adye (1801), op. cit., p. 115 and (1813), p. 203.

13 RAI, Glegg, op. cit., pp. 115-16.

14 Hughes, *Smooth-Bore*, op. cit., p. 28.

15 RAI, James, op. cit., p. 27.

16 Ibid., p. 22.

17 RAI, Glegg, op. cit., pp. 115-16.

18 RAI, Williamson, Collection, *circa* 1770, pp. 102-3; RAI, "Experiments with long and round Shot ... 1774", unpaginated; RAI, Bogue, op. cit., pp. 141-2; Adye (1801), op. cit., (1801), p. 115 and (1813), p. 203.

19 *Aide-Mémoire* (1850), op. cit., Vol. 2, pp. 520-1.

20 Smith, op. cit., p. 285; *Aide-Mémoire* (1850), op. cit., p. 514; RAI, Landmann, "Notes on Artillery," p. 12. See also note 18.

21 Adrian Caruana, *Grasshoppers and Butterflies: The Light 3-Pounders of Pattison and Townshend* (Bloomfield, Ont: Museum Restoration Service, 1980), p. 5.

22 RAI, "Artillery Practice & Stores," *circa* 1780, pp. 1-2; RAI, Bogue, op. cit., pp. 141-2; Adye (1801), op. cit., p. 115 and (1813), p. 203.

23 RAI, Landmann, "Notes on Artillery," p. 13; Adye (1801), op. cit., p. 115 and (1813), p. 203.

24 Hughes, *Smooth-Bore*, op. cit., p. 28.

25 RAI, Portfolio of drawings, *circa* 1735, plates 50, 53.

26 J.P. Kaestlin, *Catalogue of the Museum of Artillery in the Rotunda at Woolwich; Part I, Ordnance*. Revised ed., n.p., 1970, II/45, p. 13.

27 RAI, Glegg, op. cit., pp. 115-16; Adye (1766), op. cit., pp. 12-14, 18-19.

28 RAI, Walton, op. cit., unpaginated.

29 Rudyerd, op. cit., plates 4-9.

30 RAI, Adye (1766), op. cit., p. 19.

31 Adye (1801), op. cit., p. 115.

32 RAI, Landmann, "Notes on Artillery," pp. 14-18.

33 RAI, James, op. cit., p. 27.

34 RAI, Portfolio of drawings, *circa* 1735, plates 51, 54.

35 RAI, Glegg, op. cit., pp. 115-16; RAI, Adye (1766), op. cit., pp. 12-14.

36 RAI, Williamson, Collections, *circa* 1770, pp. 17, 102-3; RAI, "Experiments with long and round Shot ... 1774", unpaginated; RAI, Walton, op. cit., 1781, unpaginated.

37 RAI, Walton, op. cit., table of 1778, unpaginated.

38 Adye (1801), op. cit., p. 115 and (1813), p. 203.

39 Smith, op. cit., p. 47.

40 Muller (1780), op. cit., p. xxii.

41 Caruana, "Grasshoppers and Butterflies," op. cit., p. 5.
42 Adye (1801), op. cit., p. 115.
43 RAI, Landmann, "Notes on Artillery," p. 13.
44 Hughes, Smooth-Bore, op. cit., p. 28.
45 RAI, James, op. cit., pp. 22, 27.
46 RAI, Portfolio of drawings, circa 1735, plate 53.
47 RA, "Experiments with long and round shot ...," unpaginated.
48 RAI, Glegg, op. cit., pp. 115-116.
49 RAI, Landmann, "Notes on Artillery," p. 12; Smith, op. cit., p. 285.
50 RAI, Adye (1766), op. cit., pp. 12-14.
51 RAI, Walton, op. cit., unpaginated.
52 Adye (1801), op. cit., p. 1
53 RAI, Glegg, op. cit., p. 140 Muller, op. cit., (1757), p. 110.
54 RAI, Landmann, "Notes on Artillery," p. 12; Smith, op. cit., p. 285.
55 Adye (1801), op. cit., p. 15 and (1813), p. 203.
56 RAI, Adye (1766), op. cit., pp. 18-19.
57 RAI, Walton, op. cit., unpaginated.
58 Ibid.
59 Adye (1801), op. cit., p. 115 and (1813), p. 203.
60 Adye (1801), op. cit., p. 115.
61 RAI, Landmann, "Notes on Artillery," p. 13. Adye in his 1801 manual, p. 115, attributed the new medium gun to Congreve, but Landmann clearly stated that it was designed by Blomefield.
62 RAI, "Collected Military Papers", Vol. 2, p. 221, Woolwich, 14 Feb. 1794, Stehelin to Richmond.
63 RMC, Mould, op. cit., p. 318.
64 Aide-Mémoire (1846), op. cit., Vol. I, pp. 58-9; RAI, E.M. Boxer, Diagrams of Guns referred to in Treatise on artillery prepared for the use of Royal Military Academy. Section 2. Part II (London: Eyre to Spottiswoode for HMSO, 1853), plate XIX.
65 Owen and Porter, op. cit., p. 65.
66 RAI, James, op. cit., p. 27.
67 Smith, op. cit., p. 285; RAI, Landmann, "Notes on Artillery," p. 12.
68 RAI, Adye (1766), op. cit., pp. 12-14.
69 RAI, Walton, op. cit., unpaginated.
70 Hughes, Smooth-Bore, op. cit., p. 71, Cf. Kaestlin, op. cit., p. 17, II/90.
71 Muller (1780), op. cit., pp. 180, 192.
72 RAI, Landmann, "Notes on Artillery," p. 13.
73 RAI, Notebook, 1805-22, "Experiments ... to ascertain the Ranges of a Brass 9 Pounder Gun of 17 Calibres," 13 Nov. 1805.
74 Hughes, Smooth-Bore, op. cit., p. 72.
75 Ibid., p. 80.
76 For detailed dimensions and a scale drawing see Aide-Mémoire (1853), op. cit., Vol. I, pp. 62-3; RAI, Boxer, Diagrams of Guns, plate XX. The Boxer drawing shows dolphins but the gun at Woolwich does not have them.
77 Kaestlin, op. cit., p. 17, II/90.
78 Ibid., p. 17, II/91. The catalogue says that the guns length is 6 feet 7 inches, but this may be its total length.
79 Kaestlin, op. cit., p. 17, II/90; Owen and Porter, op. cit., p. 90.
80 RAI, James, op. cit., p. 27.
81 RAI, Portfolio of drawings, circa 1735, plates 50/3, 54.
82 RAI, Williamson, Collections, circa 1770, pp. 102-3.
83 RAI, Glegg, op. cit., pp. 115-116; RAI, Landmann, "Notes on Artillery," p. 12;

Smith, op. cit., p. 285.
84 RAI, Adye (1766), op. cit., pp. 12-14; RAI, Walton, op. cit., unpaginated.
85 Kaestlin, op. cit., p. 14, II/59. This gun weighed 19 cwt. 2 qr. 6 lb.
86 Adye (1813), op. cit., p. 203.
87 RAI, Landmann, "Notes on Artillery," p. 12; Smith, op. cit., p. 285.
88 Muller (1780), op. cit., pp. v, 180, 192.
89 RAI, Glegg, op. cit., p. 140.
90 Kaestlin, op. cit., p. 13, II/48. This gun weighed 4 cwt. 2 qr. 22 lb.
91 RAI, Adye (1766), op. cit., pp. 18-19.
92 Rudyerd, op. cit., plate 10.
93 RAI, Walton, op. cit., unpaginated.
94 Ibid.; RAI, Experiments Woolwich 1778-1779, unpaginated; RAI, "Practice with Case Shot from Two Six Pounders of the new Construction...," Winchester, 30 Oct. 1780, unpaginated; RAI, "Practice with Two Light Six Pounders of the new Construction," Winchester, 25 Sept.-26 Oct. 1780; RAI, "Artillery Practice, & Stores," Part I, pp. 1-2; Part II, pp. 45-53, Aug. and Sept. 1780.
95 Adrian Caruana, The Light 6-Pdr. Battalion Gun of 1776 (Bloomfield, Ont.: Museum Restoration Service, 1977), p. 5.
96 RAI, Landmann, "Notes on Artillery," p. 6.
97 Adye (1813), op. cit., p. 203.
98 RAI, Landmann, "Notes on Artillery," p. 12; Smith, op. cit., p. 285.
99 RAI, Walton, op. cit., unpaginated.
100 Kaestlin, op. cit., p. 14, II/65-66.
101 Adye (1801), op. cit., p. 115 and (1813), p. 203.
102 RMC, Mould, op. cit., p. 318.
103 DNB, Vol. 4, pp. 146-7.
104 RAI, Walton, op. cit., unpaginated.
105 RAI, "Experiments Woolwich 1778-1779," unpaginated; RAI, "Artillery Practice & Stores," Part II, 45-53.
106 RAI, Trials Goodwood, 1792, unpaginated.
107 Kaestlin, op. cit., p. 15, II/12.
108 Adye (1813), op. cit., p. 203.
109 RAI, Walton, op. cit., unpaginated. The position of these tables after others of 1792 is hardly conclusive, since they could be copied into the notebook after 1792 although the experiments were actually carried out sometime previously.
110 Adye (1801), op. cit., p. 115 and (1813), p. 203.
111 RAI, Landmann, "Notes on Artillery," p. 13.
112 RAI, Boxer, Diagrams of Guns, plate XXI.
113 Blackmore, op. cit., p. 81, No. 68.
114 Kaestlin, op. cit., p. 17; Miller, op. cit., p. 160.
115 RAI, Shuttleworth Collection, 2 sketches of a light 6-pounder, circa 1820.
116 Aide-Mémoire (1846), op. cit., Vol. I, pp. 58-9 and (1853), Vol. I, pp. 62-3; RAI, Boxer, op. cit., plate XXI.
117 Blackmore, op. cit., pp. 86-8, Nos. 82, 84, 85.
118 Owen and Porter, op. cit., p. 65.
119 RAI, James, op. cit., p. 27.
120 RAI, Portfolio of drawings, circa 1735, plate 53.
121 RAI, Glegg, op. cit., pp. 115-116; RAI, Adye, (1766), op. cit. pp. 12-14.
122 Blackmore, op. cit., pp. 71-2.
123 RAI, Landmann, "Notes on Artillery," op. cit., p. 12; Smith, op. cit., p. 285.
124 Adye (1801), op. cit., p. 115 and (1813), p. 203.
125 Kaestlin, op. cit., p. 14, II/63.
126 RAI, Walton, op. cit., unpaginated.

127 Kaestlin, op. cit., p. 13, II/49.
128 RAI, Landmann, "Notes on Artillery," op. cit., p. 12; Smith, op. cit., p. 285; RAI, Adye (1766), op. cit., pp. 18-19.
129 RAI, Walton, op. cit., unpaginated.
130 Kaestlin, op. cit., p. 15, II/67.
131 Adye (1801), op. cit., p. 115 and (1813), p. 203.
132 Caruana, *Grasshoppers and Butterflies*, op. cit., p. 3; cf. Jackson and de Beer, op. cit., p. 533.
133 Caruana, *Grasshoppers and Butterflies*, op. cit., passim; RAI, "Description and Utility of the Portable 3 P^{r} Brass Cannon and Carriage," *circa* 1774, in Trials, Woolwich, 1774 , unpaginated; RAI, "Return of the Weight of Saddles, Ammunition, Gun, Carriage, &^{c}: of Light 3 Pounders (or Grasshoppers)3^{d} August 1776 in "Artillery Experiments, 1770-1; 1773," unpaginated.
134 RAI, Walton, op. cit., unpaginated.
135 Adye (1801), op. cit., p. 115 and (1813), p. 203.
136 Caruana, *Grasshoppers and Butterflies*, op. cit., pp. 3-16; RAI, Adye (1766), op. cit., p. 19.
137 RAI, Trials, Woolwich, 1774 , op. cit., unpaginated; RAI, "Artillery Experiments, 1770-1; 1773," op. cit., unpaginated; RAI, Walton, op. cit., various tables, unpaginated; Adye (1801), op. cit., p. 115 and (1813), p. 203.
138 RAI, Landmann, "Notes on Artillery," p. 13.
139 Four of the guns are at Lower Fort Garry, Manitoba, and two are at the Carleton Martello Tower, St. John, N.B.; Blackmore, op. cit., p. 84, Nos. 74-6; Kaestlin, op. cit., p. 16, II/79.
140 The Environment Canada – Parks gun is at Lower Fort Garry, Manitoba. Blackmore, op. cit., p. 84.
141 Adye (1827), op. cit., p. 192; Spearman (1828), op. cit., pp. 154, 244; Griffiths (1839), op. cit., p. 52, (1852), p. 60 and (1862), p. 62.
142 RMC, Mould, op. cit., p. 318.
143 *Aide-Mémoire* (1846), op. cit., Vol. I, pp. 58-9 and (1853), Vol. I, pp. 62-3; RMC Noble, op. cit., p. 228.
144 Kaestlin, op. cit., p. 17, II/88; Owen and Porter, op. cit., p. 65.
145 Adye (1801), op. cit., p. 115 and (1813), p. 203; RMC, Mould, op. cit., p. 318; *Aide-Mémoire*, (1846), op. cit. Vol. I, pp. 58-9 and (1853), Vol. I, pp. 62-3.
146 RAI, Landmann, "Notes on Artillery," pp. 19-34. The construction outlined is for a Desaguliers' 6-pounder of 7 feet, but it is assumed that the proportions would be the same for a 3-pounder of 6 feet.
147 RAI, James, op. cit., p. 27.
148 RAI, Portfolio of drawings, *circa* 1735, plate 54.
149 RAI, Glegg, op. cit., p. 115-116; RAI, Landmann, "Notes on Artillery," p. 12; Smith, op. cit., p. 285.
150 RAI, Walton, op. cit., unpaginated.
151 RAI, Adye (1766), op. cit., pp. 12-14.
152 RAI, James, op. cit., p. 27; Kaestlin, op. cit., p. 14, II/64.
153 Blackmore, op. cit., p. 218.
154 Ibid., p. 218.
155 Kaestlin, op. cit., p. 14, II/61.
156 Blackmore, op. cit., p. 218; RAI, "Experiments, Woolwich, 1778-1779," unpaginated; RAI, Walton, op. cit., unpaginated.
157 Kaestlin, op. cit., p. 15, II/70.
158 RAI, "Experiments, Woolwich, 1778-1779," unpaginated; RAI, Walton, op. cit., unpaginated.
159 Blackmore, op. cit., p. 78. There is also a record of tests in Oct. 1792. RAI,

Trials, Goodwood, 1792, unpaginated.
160 RAI, Landmann, "Notes on Artillery," p. 13.
161 Blackmore, op. cit., p. 78.
162 RMC, Mould, op. cit., p. 318; Adye (1827), op. cit., p. 192; *Aide-Mémoire* (1846), op. cit., Vol. I, pp. 58-9 and (1853), Vol. I, pp. 61-3; Griffiths (1862), op. cit., p. 62.
163 RAI, Walton, op. cit., unpaginated.
164 *DNB*, Vol. 14, pp. 401-2.
165 RAI, Landmann, "Notes on Artillery," pp. 29-34.
166 RAI, Walton, op. cit., unpaginated.

Cast Iron Guns

1 Major Miller, *Equipment on Artillery, Forming Part II of the Series relating to Army Equipments* (London: Eyre & Spottiswoode for HMSO [1864], p. 297.
2 Sir Howard Douglas, *A Treatise on Naval Gunnery*. 5 editions (London: John Murray, 1820-60), pp. 179-80; Miller, op. cit., p. 295; Owen and Porter, p. 65.
3 Owen and Porter, op. cit., p. 65. No references to these guns have been found till after 1846.
4 Owen, Elementary, op. cit., p. 28; Great Britain. Public Records Office [Henceforth PRO], W033/7, Report of the Committee on Ordnance, 26 July 1859, p. 2.
5 PRO, W033/7, Report of the Committee on Ordnance, p. 2.
6 Owen, Elementary, op. cit., p. 28.
7 Miller, op. cit., p. 297.
8 PRO, W033/7, Report of the Committee on Ordnance, p. 5.
9 Owen and Porter, op. cit., p. 58.
10 *Quarterly List of Changes in Military Stores, from January 1860 to December 1867* (London: Eyre and Spottiswoode for Her Majesty's Stationery Office, 1860-8.), 1 Jan. 1866, approved 28 Nov. 1865, 1140 [Henceforth *Quarterly Lists of Changes*].
11 Ibid.
12 RAI, Boxer, *Diagrams of Guns*, Plate II.
13 *Aide-Mémoire* (1846), Vol. I, op. cit., pp. 56-57; (1853), Vol. I, op. cit., pp. 60-1.
14 Miller, op.cit., p. 296.
15 Douglas (1860), op. cit., p. 178; "A Synoptical Table of the Deal Practice carried on in the Year 1839," *Proceedings of the Royal Artillery Institution* (Vol. I), 1858, No. 15.
16 Miller, op. cit., p. 304.
17 DND, Fitzhugh, op. cit., pp. 8-10.
18 RAI, Strange, op. cit., "Lt. Col. Dundas's 56 Pr. of 11 feet and 98 cwt."
19 RAI, Boxer, *Diagrams of Guns*, Plate V; *Aide-Mémoire* (1853), Vol. I, op. cit., pp. 60-1; Miller, op. cit., p. 302.
20 PRO, W033/7, "Report of the Committee on Ordnance," 26 July 1859, pp. 6-7.
21 Miller, op. cit., p. 304.
22 J.H. Lefroy, *Handbook for Field Service*. 4th ed. (Woolwich. Boddy, 1867), p. 74.
23 RAI, Reports on Artillery, "Confidential Circulars. Abstract of Recommendations and Observations taken from a report of a Committee of Officers of the Royal Artillery and Royal Engineers...for Coast Batteries... reported 5th. November 1852...approved 1853. M/612." p. 9; Douglas (1851), op. cit., p. 581, "These 56-pounders give place to 68 prs. when ships at sea are recommissioned."
24 PRO, W033/7, "Report of the Committee or Ordnance," pp. 6-7.
25 Ibid., pp. 6-7.

26 *Quarterly List of Changes*, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

27 RAI, James, op. cit., p. 27.

28 RAI, Portfolio, *circa* 1735, Plate 51.

29 Smith, op. cit., p. 47; Muller (1757), op. cit., p. 105. Muller does not give a specific date. See also Miller, op. cit., p. 307.

30 Smith, op. cit., p. 286; RAI, Congreve, "Exercise and Manoeuvres for two light six Pounders...," unpaginated; RAI, Landmann, "Notes on Artillery," p. 11.

31 RAI, Walton, op. cit., unpaginated.

32 RAI, "Artillery Practice & Stores," *circa* 1780, pp. 12, 92.

33 William Mountaine, *The Practical Sea-Gunners' Companion; or an Introduction to the Art of Gunnery...*, London: Mount, Page, 1782, p. 70.

34 RAI, Landmann, "Notes on Artillery," p. 35.

35 Adye (1801), op. cit., p. 116 and (1813), p. 204.

36 RMC, Mould, op. cit., p. 315.

37 Douglas (1860), op. cit., pp. 182, 178.

38 "A Syntopical Table of the Deal Practice carried on in the Year 1839." *Proceedings of the Royal Artillery Institution*, Vol. I (1858), No. 15.

39 Miller, op. cit., p. 305; Owen and Porter, op. cit., p. 65.

40 Miller, op. cit., pp. 306-7.

41 Ibid., p. 307. *Aide-Mémoire* (1853), op. cit., Vol. I., p. 60, indicates the designer of the two guns of 10 feet was Millar; this must be an error, for Millar committed suicide in 1838.

42 RAI, Reports on Artillery, "Abstract of Recommendations and Observations... for Coast Batteries...1853," p. 9.

43 Douglas (1860), op. cit., p. 184.

44 RAI, Reports on Artillery, "Confidential Papers submitted to the Committee on Ordnance..." [1857-9], p. 43.

45 *Quarterly List of Changes*, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

46 Owen and Porter, op. cit., p. 58.

47 *Aidé-Mémoire* (1845), op. cit., Vol. I, pp. 56-7.

48 *Aide-Mémoire* (1853), op. cit., Vol. I, pp. 60-1; RAI, Boxer, *Diagrams of Guns*, Plate VI, "42 Pounder Iron Gun."

49 RAI, Reports on Artillery, "...Papers submitted to the Committee on Ordnance...," [1857-9], pp. 9, 30, 40-1, 43; PRO, W033/7, Report of the Committee on Ordnance, 26 July 1859, pp. 3, 6-7.

50 RAI, James, op. cit., p. 27.

51 RAI, Glegg, op. cit., pp. 117-18.

52 RAI, Adye (1766), op. cit., pp. 15-17.

53 Blackmore, op. cit., p. 74.

54 Smith, op. cit., p. 286; RAI, Congreve, "Exercise and Manoeuvres for two light six Pounders...," unpaginated; RAI, Landmann, "Notes on Artillery," p. 11; *Aide-Mémoire* (1850), op. cit., Vol. 2, p. 515.

55 RAI, Walton, op. cit., unpaginated.

56 Ibid.

57 Adye (1801), op. cit., p. 116 and (1813), p. 204.

58 RAI, Landmann, "Notes on Artillery," p. 35.

59 RAI, Reports on Artillery, "...Papers submitted to the Committee on Ordnance...," [1857-9], p. 54, H.D. Chads to the Secretary of the Admiralty, Portsmonth, 20 May, 1851.

60 PRO, W033/7, Report of the Committee on Ordnance, 26 July 1859, p. 6.

61 *Quarterly List of Changes*, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

62 RMC, Mould, op. cit., p. 315.

63 PRO, W033/7, Report of the Committee on Ordnance, 26 July 1859, p. 6.

64 Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

65 RAI, Boxer, Diagrams of Guns, op. cit., Plate VII; Aide-Mémoire (1853), op. cit., Vol. I, pp. 60-1.

66 Douglas (1851), op. cit., p. 581; Aide-Mémoire (1853), op. cit., Vol. I, pp. 60-1; RAI, Boxer, Diagrams of Guns, op. cit., Plates VII, X; Miller, op. cit., pp. 310-13; Lefroy (1867), op. cit., pp. 71-2, 74. Concerning the bored-up 32 pdr., 8 feet and 41 hundredweight, Douglas and Lefroy say that it was originally a 24-pdr., but the Aide-Mémoire, Boxer, and Miller claim that it was an 18-pounder (Boxer says of 42 cwt). No record can be found of an 18-pdr., 8 feet and 42 cwt; the 18-pdr. of 8 feet weighed 37 cwt. There is a record of a 24-pdr. of 8 feet weighing 43 cwt.

67 Douglas (1860), op. cit., pp. 165-70.

68 Quarterly List of Changes, 1 Jan. 1866, approved 28, Nov. 1865, 1140.

69 DNB, Vol. 15, pp. 39-41 and Vol. 37, p. 404.

70 Miller, op. cit., pp. 308, 314.

71 Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

72 Lefroy (1867), op. cit., p. 73.

73 RMC, Noble, op. cit., "General Millar's Construction," unpaginated; RAI, Drawings on Artillery, "General Millers sic Construction," unpaginated; Miller, op. cit., p. 311.

74 Owen and Porter, op. cit., pp. 58-9.

75 PRO, W033/7, Report of the Committee on Ordnance, 26 July 1859, p. 7; Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

76 Miller, op cit., pp. 308, 314; RAI, Boxer, Diagrams of Guns, op. cit., Plate X.

77 PRO, W033/7, Report of the Committee on Ordnance, 26 July 1859, p. 3.

78 Ibid., pp. 6-7; Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

79 Douglas (1860), op. cit., pp 178, 180-1.

80 Miller, op. cit., pp. 310-12.

81 RAI, Reports on Artillery, "Abstract of Recommendations and Observations ... for Coast Batteries...1853," p. 9, handwritten note.

82 Miller, op. cit., p. 315; Owen and Porter, op. cit., p. 58.

83 Douglas (1860), op. cit., pp. 180-1.

84 Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

85 RAI, Reports on Artillery, "...Papers submitted to the Committee on Ordnance, November 23, 1857...," Nos. 30-46, pp. 50-59. A series of letters and tables from 1846 to 1853 concerning the tests.

86 Ibid., p. 40.

87 Ibid., "Confidential Circular," Horse Guards, 1 Jan. 1861. Report of a Committee of Ordnance to revise Confidential Circular of 1853, M/61, Woolwich, July 1860. On page 1 the weight of the 32-pounder was given as 56 cwt., but the table on p. 14 gave the weight at 58 cwt.

88 Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

89 Owen and Porter, op. cit., n., p. 58.

90 Miller, op. cit., p. 314.

91 Douglas (1851), op. cit., p. 581. Inexplicably it was not included in the tables of dimensions in the Aide-Mémoire (1853), Vol. I, op. cit., pp. 60-1.

92 RAI, Reports on Artillery, "...Papers submitted to the Committee on Ordnance, November 23, 1857...," p. 40.

93 Lefroy (1867), op. cit., p. 71. Cf. Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140, in which a bored up 32-pounder of 6 ft. and 25 cwt. was included in both lists. Presumably an error was made.

94 Lefroy (1867), op. cit., p. 73.

95 William Congreve, *A Concise Account of the Origin & Principles of the New Class of 24-Pounder Medium Guns of Reduced Length and Weight...* (London: Egerton, 1820); Douglas (1860), op. cit., pp. 98-9. Later criticisms and tests by the Board of Ordnance in 1814 were distinctly unfavourable to the Congreve gun and the Royal Artillery never adopted the weapon. For a full account of these criticisms and tests see Adrian Caruana, "The Carronade Gun," Vol. 23, No. 4 (Nov. 1985), pp. 129-36.

96 RMC, Mould, op. cit., p. 315. See also p. 104 for a diagram of "Congreve's 24-Pr. Carronade Gun."

97 "Congreve's Guns," *United Service Journal*, No. 35 (Oct. 1831) pp. 390-1. A letter signed "Blue Jacket," dated 14 Sept. 1831.

98 Douglas (1860), op. cit., pp. 177-8.

99 "Congreve's Guns," op. cit., pp. 390-1.

100 Congreve, *A Concise Account...*, op. cit., p. 23.

101 PRO, W033/7, Report of the Committee on Ordnance, 26 July 1859, p. 7; RAI, Reports on Artillery, "...Papers submitted to Committee on Ordnance...," [1857-59], pp. 28-9.

102 Douglas (1860), op. cit., p. 165.

103 *Quarterly List of Changes*, 1 Jan. 1860, approved 28 Nov. 1865, 1140.

104 RAI, James, op. cit., p. 27.

105 RAI, Glegg, op. cit., pp. 117-18.

106 RAI, Adye (1766), op. cit., pp. 15-17.

107 Smith, op. cit., p. 286; RAI, Congreve, "Exercise and Manoeuvres for two Light six Pounders...," unpaginated; *Aide-Mémoire* (1850), op. cit., Vol. 2, p. 515.

108 RAI, Landmann, "Notes on Artillery," p. 11.

109 RAI, Walton, op. cit., unpaginated; RAI, "Artillery Practice & Stores" (*circa* 1780), pp. 89-90. The weight of the gun of 9-1/2-feet was given as 49-1/2, rather than 49, hundredweight.

110 RAI, "Artillery Practice & Stores" (*circa* 1780), p. 12; Adye (1801), op. cit., p. 116 and (1813), p. 204.

111 RAI, Landmann, "Notes on Artillery," p. 35.

112 RMC, Mould, op. cit., p. 315.

113 Hughes, *Smooth-Bore Artillery*, op. cit., pp. 90-92.

114 Congreve, *A Concise Account...*, op. cit., p. 3; Douglas, (1860), op. cit., pp. 98-9.

115 RMC, Mould, op. cit., p. 315.

116 Spearman (1828), op. cit., p. 155; "Matériel of Artillery...," 1 Jan. 1866, approved 28 Nov. 1865, 1140.

117 RMC, Mould, op. cit., p. 315.

118 *Quarterly List of Changes*, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

119 A.B. Caruana, "The Short 32 Pr. Iron," unpublished report for Halifax Defence Complex, Environment Canada — Parks, 1983, citing "Notes on Artillery" by J. Cockburn and D.W. Payntor; Douglas (1860), op. cit., p. 98, refers to a 24-pdr. of 6-1/2-feet being used in experiments on Sutton Heath in 1810.

120 RMC, Mould, op. cit., p. 315.

121 RAI, Boxer, *Diagrams of Guns*, op. cit., Plate XIII; Miller, op. cit., p. 318.

122 *Quarterly List of Changes*, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

123 See section on 32-pdr.

124 Marcom Museum, CFB Stadacona, Halifax, Proof Book, Woolwich, March 1800 - June 1801. Untitled MS, unpaginated.

125 RMC, Mould, op. cit., p. 316.

126 RMC, Noble, op. cit., p. 73," A return of Iron Ordnance in the Service July 6th 1847" noted a 24-pdr. of 8 feet and 37 cwt., but does not indicate that it was

bored up.

127 Aide-Mémoire (1853), op. cit., Vol. I, pp. 60-1; PRO, W033/7, Report of the Committee on Ordnance, 26 July 1859, p. 7. The Aide-Mémoire noted that it was a bored-up 18-pdr.

128 Douglas (1860), op. cit., p. 605; Aide-Mémoire (1853), op. cit., Vol. I, pp. 60-1; Miller, op. cit., p. 318.

129 Miller, op. cit., p. 319.

130 Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

131 Aide-Mémoire (1853), op. cit., Vol. I, pp. 60-1.

132 RAI, Reports on Artillery, "...Papers submitted to the Committee on Ordnance, November 23, 1857...," pp. 9, 28.

133 Ibid., pp. 9, 28.

134 Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

135 RAI, James, op. cit., p. 27.

136 RAI, Portfolio of drawings, circa 1735, Plate 50.

137 RAI, Glegg, op. cit., pp. 117-18; RAI, Adye (1766), op. cit., pp. 15-17.

138 RAI, Williamson, "Collections ...," pp. 86-7; Muller (1780), op. cit., p. xiii.

139 National Archives of Canada (henceforth NA), RG8, I, Vol. 406, pp. 130-1, Hillier to Bowles, 1 April 1820.

140 J. Mackay Hitsman, The Incredible War of 1812 (Toronto: University of Toronto Press, 1965), pp. 123-4.

141 PRO, W033/7, Report of the Committee on Ordnance, 26 July 1859, p. 7.

142 Smith, op. cit., p. 286; RAI, Congreve, "Exercise and Manoeuvres for two Light six Pounders...," unpaginated; RAI, Landmann, "Notes on Artillery," p. 11; Aide-Mémoire (1850), op. cit., Vol. 2, p. 515.

143 RAI, Walton, op. cit., unpaginated.

144 Ibid.; RAI, "Artillery Practice & Stores" (circa 1780), p. 12.

145 Adye (1801), op. cit., p. 116 and (1813), p. 204.

146 RAI, Landmann, "Notes on Artillery," p. 35.

147 Marcom Museum, CFB Stadacona, Halifax, Proof Book, Woolwich, March 1800 - June 1801. Untitled MS, unpaginated.

148 RMC, Mould, op. cit., p. 316.

149 Spearman (1844), op. cit., unpaginated; Aide-Mémoire (1853), op. cit., Vol. I, pp. 60-1.

150 RAI, Boxer, Diagrams of Guns, Plate XV; Aide-Mémoire (1853), op. cit., Vol. I, pp. 60-1; Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

151 Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.

152 RAI, James, op. cit., p. 27.

153 RAI, Glegg, op. cit., pp. 117-18.

154 RAI, Adye (1766), op. cit., pp. 15-17. The only significant difference was that the mensuration had the length of the first reinforce at 30 in., while Adye put it at 29 in.

155 RAI, Walton, op. cit., unpaginated.

156 RAI, Landmann, "Notes on Artillery," p. 11; RAI, Congreve, "Exercise and Manoeuvres for two Light six Pounders...," unpaginated; Smith, op. cit., p. 286; Aide-Mémoire (1850), op. cit., Vol. 2, p. 515.

157 RAI, Landmann, "Notes on Artillery," pp. 1-5.

158 Ibid., p. 35. See C.W. Rudyerd, Course of Artillery at the Royal Military Academy as established by his Grace the Duke of Richmond Master General of His Majestys Ordnance etc. etc., 1793 (Ottawa: Museum Restoration Service, 1970), Plate II, "Draught of an Iron 12 Pounder Sea Service Gun of 7-1/2-feet in length shewing the general Principle upon which Iron Sea Service Guns are constructed." This is a Blomefield construction.

159 See 24-pounders at Fort Henry, bored up from the 12-pounders of 21 cwt; RAI, Boxer, Diagrams of Guns, Plate XVI," 12 Pounder Iron Gun." Concerning the 6 foot gun of 21 cwt., "The mouldings at the cascable and muzzle are different from the drawing of this gun," i.e. the normal Blomefield pattern.

160 RMC, Mould, op. cit., p. 316.

161 Miller, op. cit., p. 325.

162 RAI, Reports on Artillery, "...Papers submitted to the Committee on Ordnance, November 23, 1857...," pp. 29, 40-1, 43. Nothing is known about the gun of 4 feet.

163 Quarterly List of Changes, 1 Jan 1866, approved 28 Nov. 1865, 1140. In the list of guns to be abolished the 18-pdr. of 6 feet and 22 cwt. was said to be a bored-up 9 pdr.; it is assumed this is an error.

164 Blackmore, op. cit., p. 70.

165 Ibid., p. 70; RAI, Borgard, Artillery Tables, "No. 30, Particular Dimentions of all the Parts of an Iron 6 Pounder Cannon Eight Foot Long According to the new Proportion given by Coll. Borgard in the Year 1716; with A Table for Surveying Iron Cannon...."

166 RAI, James, op. cit., p. 27.

167 RAI, Portfolio of drawings, circa 1735, Plate 52. The only major difference was that the length of the first reinforce in the 1735 drawing was 30.8 inches, while in 1743 and 1766 it was given as 28 inches. The second reinforce was the same, but the chase, the length of which was not specifically given, would vary accordingly.

168 RAI, Landmann, "Notes on Artillery," p. 11; RAI, Congreve, "Exercise and Manoeuvres for two Light six Pounders...," unpaginated; Smith, op. cit., p. 286; Aide-Mémoire (1850), op. cit., Vol. 2, p. 515.

169 RAI, Walton, op. cit., unpaginated.

170 Ibid.

171 RAI, Landmann, "Notes on Artillery," p. 35.

172 Adye (1801), op. cit., p. 116 and (1813), p. 204. There are 3 Blomefield general service 9-pounders at Fort Amherst N.H.P., Prince Edward Island, which are, surprisingly, 6 ft. 4 in. in length, weight unknown, bearing the monogram of King George III.

173 RMC, Mould, op. cit., p. 316.

174 RAI, Boxer, Diagrams of Guns, Plate XVII, "9 Pounder Iron Gun."

175 DND, Fitzhugh, op. cit., pp. 8-10.

176 PRO, W033/7, Report of the Committee on Ordnance, 1859, pp. 6, 8.

177 Miller, op. cit., p. 327.

178 PRO, W033/7, Report of the Committee on Ordnance, 1859, pp. 6,8.

179 Quarterly List of Changes, 1 Jan. 1860, approved 28 Nov. 1865, 1140.

180 RAI, Borgard Artillery Tables, "No. 30, Particular Dimensions of all the parts of an Iron 6 Por. of 8 feet long, according to Col. A. Borgard's proportion in 1716; with a Table for surveying Iron Cannon."

181 RAI, James, op. cit., p. 27. It is assumed that the measurement was made from the rear, not the front, of the base ring.

182 RAI, Portfolio, op. cit., circa 1735, Plate 52.

183 RAI, Glegg, op. cit., pp. 117-18.

184 RAI, Adye (1766), op. cit., pp. 15-17.

185 Smith, op. cit., p. 286; RAI, Congreve, "Exercise and Manoeuvres for two light six Pounders...," unpaginated; RAI, Landmann, "Notes in Artillery," p. 11; Aide-Mémoire (1850), op. cit., Vol. 2, p. 515.

186 RAI, Walton, op. cit., unpaginated.

187 RAI, Landmann, "Notes on Artillery," p. 35.

188 RMC, Mould, op. cit., pp. 316-17. Adye (1827), op. cit., p. 194 also lists them along with the naval service gun of 6 feet.
189 DND, Fitzhugh, op. cit., pp. 8-10. "Nine and six Pdrs. (iron) are now little used except sometimes for saluting."
190 Aide-Mémoire (1845), op. cit., Vol. I, pp. 56-7 and (1853), Vol. I, pp. 60-1.
191 RAI, Reports on Artillery, "...Papers submitted to the Committee on Ordnance...," p. 40.
192 Ibid, p. 29.
193 PRO, W033/7, Report of the Committee on Ordnance, 26 July 1859, p. 8.
194 Quarterly List of Changes, 1 Jan. 1866, approved 28 Nov. 1865, 1140.
195 RAI, James, op. cit., p. 27.
196 It is on display at the National Maritime Museum, Greenwich.
197 Muller (1757), op. cit., p. 105; Smith, op. cit., p. 47.
198 Smith, op. cit., p. 286; RAI, Congreve, "Exercise and Manoeuvres for two light six Pounders...," unpaginated; Landmann, "Notes on Artillery," p. 11; Aide-Mémoire (1850), op. cit., Vol. 2, p. 515.
199 RAI, Walton, op. cit., unpaginated; "Experiments Landguard Fort 1780," unpaginated; Adye (1801), op. cit., p. 116 and (1813), p. 204.
200 RAI, Walton, op. cit., unpaginated.
201 Kaestlin, op. cit., p. 36, III/29.
202 RAI, Landmann, "Notes on Artillery," p. 35. Its weight was not given.
203 RMC, Mould, op. cit., p. 317.
204 NA, RG 8, I, Vol. 750, pp. 65-8, Macbean to Cubitt, 27 Nov. 1838.
205 RAI, James, op. cit., p. 27.
206 RAI, Glegg, op. cit., pp. 117-18.
207 Smith, op. cit., p. 286; RAI, Congreve, "Exercise and manoeuvres for two light six Pounders...," unpaginated; RAI, Landmann, "Notes on Artillery," p. 11; Aide-Mémoire (1850), op. cit., Vol. 2, p. 515.
208 RAI, Adye (1766), op. cit., pp. 15-17; RAI, Walton, op. cit., unpaginated.
209 RAI, Landmann, "Notes on Artillery," p. 35. Its weight was not given.
210 Adye (1801), op. cit., p. 116 and (1813), p. 204.
211 RAI, Reports on Artillery, "...Papers submitted to the Committee on Ordnance...," p. 29.

Shell-Guns

1 Frederick L. Robertson, The Evolution of Naval Armament. Reprint of 1921 ed. (London: Harold T. Storey, 1968), p. 161.
2 Ian Hogg and John Batchelor, Naval Gun (Poole, Dorset; Blandford Press, 1978), pp. 24-5.
3 Robertson, op. cit., pp. 166-7.
4 Robertson, op. cit., p. 163 and footnote.
5 Ibid., p. 162-3; Hogg and Batchelor, op. cit., p. 25.
6 Robertson, p. 165; Hogg and Batchelor, op. cit., p. 26.
7 Robertson, op. cit., pp. 163-5, 174-5.
8 Ibid., pp. 166-73; Hogg and Batchelor, op. cit., pp. 26-7.
9 Robertson, op. cit., pp. 173-6; Hogg and Batchelor, op. cit., pp. 28, 30.
10 RAI, "Mem. of Colonel Millars 68 Pr. Gun of 10 Calibres & Cwt. 50.0.0," 1820-3, pp. 2-4, practice of 20 and 21 Sept. 1820.
11 Douglas (1860), op. cit., p. 178, 184-5; Miller, op. cit., p. 93.
12 RMC, Mould, op. cit., p. 315.
13 Douglas (1860), op. cit., p. 185.
14 Capt. Wilford, "Remarks on Casemated Batteries in general, and their special applications to Sea Defences; with some observations on the armament and

service of Sea Batteries," 31 Dec. 1845, Minutes of Proceedings of the Royal Artillery Institution, Vol. I (1858), p. 17.

15 RMC, Lloyd, op. cit. pp. 26-7; Owen, Elementary, op. cit., pp. 29-30.

16 RAI, Report on Artillery, "...Papers submitted to the Committee on Ordnance...," Nov. 23, 1857, p. 43, "List of Iron Ordnance considered Obsolete, and recommended by the Committee to be removed from the Effective List"; Lefroy, (1867) op. cit., p. 72, citing "War Office circular, No. 8, N.S., 1 Jan. 1866.

17 Douglas (1860), op. cit., pp. 15, 178.

18 Miller, op. cit., p. 294; Owen and Porter, op. cit., p. 65.

19 Spearman (1844), op. cit.

20 Douglas (1851), op. cit., p. 58, List dated 5 May, 1848; RAI, Report on Artillery, "...Papers submitted to the Committee on Ordnance...," 23 Nov. 1857, pp. 29, 40.

21 Ibid., p.43; Owen and Porter, op. cit., p. 65, Table III, List A.

22 Miller, op. cit., p. 294; Owen and Porter, op. cit., p. 65.

23 Miller, op. cit., p. 294.

24 Owen and Porter, op. cit., pp. 58, 65.

25 Griffiths (1839), op. cit., p. 51.

26 Spearman (1844), op. cit.

27 Miller, p. 294.

28 RAI, Report on Artillery, "...Papers submitted to the Committee on Ordnance...," 23 Nov. 1857, pp. 19, 40, 43.

29 Owen and Porter, op. cit., p. 65; Griffiths (1847), op. cit., p. 69.

30 Douglas (1860), op. cit., p. 175; RMC, Lloyd, op. cit., pp. 26-7.

31 RAI, Report on Artillery, "Minutes of the Committee on Ordnance," 24 Feb. 18581; Order dated 28 Nov. 1859, cited in Owen, Elementary, op. cit., pp. 29-30.

32 Douglas (1860), op. cit., p. 275.

33 Lefroy, (1867) op. cit., p. 71.

34 Owen and Porter, op. cit., p. 58. Both Lefroy and Owen and Porter in noting the gun's weight of 54 cwt. also credit the design to Colonel W.B. Dundas who had been inspector of artillery in the 1840s and early 1850s. Whether it is meant that he was responsible for redesigning the gun or merely that it was done based on his principle is not clear.

35 RAI, Report on Artillery, "Papers Submitted to the Committee on Ordnance," 23 Nov. 1857, pp. 8, 43.

36 Douglas (1860), op. cit., pp. 184-5, 270.

37 Miller, op. cit., p. 290.

38 "A Synoptical Table of the Deal Practice carried on in the Year 1839," Minutes of the Proceedings of the Royal Artillery Institution (Vol. I, 1858), No. 15.

39 Wilford, op cit., pp. 16-17.

40 Douglas (1860), op. cit., p. 270; Miller, op. cit., p. 289. The Dundas model was 1/3 inch longer behind the base ring and 1.15 inch more in diameter at the breech.

41 RAI, Report on Artillery, "Papers submitted to the Committee on Ordnance," 23 Nov. 1857, p. 40.

42 Ibid., "Minutes of Committee on Ordnance," 24 Feb. 1858.

43 Douglas (1860), op. cit., p. 270; NA, PAC, RG8, C Series, Vol. 1664, p. 3, "Confidential Circular," 1 Jan. 1861.

44 Owen (1873), op. cit., pp. 41-2; Owen and Porter, op. cit., p. 66, Table IV, List B, citing Changes in paterns, 1 Jan. 1866.

45 Owen and Porter, op. cit., p. 58.

46 Miller, op. cit., p. 290. Some sources gave the weights as 56 and 62 cwt.

respectively. Spearman (1828), op. cit., p. 245, recorded the gun of 7 feet 6 inches, which suggest that it may have been cast a year earlier than Miller indicated.

47 RAI, Report on Artillery, "Papers submitted to the Committee on Ordnance," 23 Nov. 1857, p. 41; "Minutes of the Committee on Ordnance," 24 Feb. 1858.

48 Owen and Porter, op. cit., p. 66, Table IV, List B, citing changes in patterns, 1 Jan. 1866.

49 Miller, op. cit., p. 290.

50 Hector Straith, *Plans Illustrative of Capt. Straith's Treatise on Fortifications and Memoire on Artillery* (London: Allen & Co., [1841]), Plate 3, fig. 29.

51 RAI, T.A. Shone, "Note Book of the late General T.A. Shone R.A."

Carronades

1 *DNB*, Vol. 48, pp. 434-6; Robertson, op. cit., pp. 121-2, 126; Hogg and Batchelor, op. cit., p. 17.

2 Muller, op. cit., pp. xxxi-ii, 38-56 passim.

3 Ibid., pp. 40, 64-5.

4 Blackmore, op. cit., pp. 144-5, Plate 45.

5 R.H. Campbell, *The Carron Company* (Edinburgh and London: Oliver and Boyd, 1961), pp. 83-90.

6 See Spencer C. Tucker, "The Carronade," *U.S. Naval Institute Proceedings*, Vol. 99, No. 8 (August, 1973), pp. 66-70, for a concise summary of the scholarship on the carronade, although citation of sources is lacking.

7 Robertson, op. cit., p. 126-7.

8 Ibid., p. 127; Cf. Hogg and Batchelor, op. cit., pp. 17, 20-1; Padfield, op. cit., p. 105; H.C.B. Rogers, *Artillery through the Ages* (London: Seeley Service & Co. Limited, 1971), p. 64.

9 Campbell, op. cit., pp. 95-103, for a judicious discussion of the evidence relating all three claimants.

10 Ibid., p. 97; RAI, Lefroy Papers, Miscellaneous, Vol. I, "Experiments made at Carron the 4 Sept.^{r} 1781 with a hundred Pounder CArronade...."

11 Campbell, op. cit., pp. 95, 98

12 Ibid., pp. 98-9.

13 Ibid., pp. 99-102.

14 Ibid., pp. 102-3.

15 Cited by Robertson, op .cit., p. 132.

16 Robertson, op. cit., pp. 130-4; Campbell, op. cit., pp. 90-4; Tucker, op. cit., pp. 66, 69; *A Description of the New-Invented Gun called a Carronade and its Uses* (Edinburgh, 18 Dec. 1779), pp. 3-7.

17 Campbell, op. cit., pp. 92-4; Robertson, op. cit., pp. 127-30; Tucker, op. cit., pp. 67-8.

18 For a contemporary statement of objections and answers see *A Description...*, op. cit., pp. 8-11.

19 Tucker, op. cit., p. 70; Robertson, op. cit., pp. 131-2, 135-6; Campbell, op. cit., p. 63.

20 RMC, Mould, op. cit., p. 317.

21 Cited by Tucker, op. cit., p. 70.

22 Hector Straith, *Treatise on Fortification and Artillery* (London: Allen and Company, 1846), pp. 556-9.

23 Ibid., pp. 559-60.

24 Miller, op. cit., p. 339.

25 Lefroy, *Handbook for Field Service*, op. cit., pp. 71-3.

26 Douglas, (1860), op. cit., p. 107.

27 Robertson, op. cit., pp. 126-7.

28 Campbell, op. cit., pp. 95-8.

29 RAI, Laboratory Notes, *circa* 1798, p. 2.

30 RMC, Mould, op. cit., p. 317.

31 Lefroy (1867), op. cit., p. 73.

32 Noble, op. cit.,, p. 73; PRO, WO 33/7, Report of the Committee on Ordnance, 1859, "List of Ordnance recommended to be considered obsolete, and got rid of," p. 8.

33 *Aide-Mémoire* (1850), op. cit., Vol. 2, p. 522.

34 *Hughes, Smooth-Bore*, op. cit., p. 41.

35 Ibid., p. 40.

36 RAI, "Experiments Woolwich 1778-1779"; RAI, "Experiments Landguard Fort 1780"; RAI, "Artillery Practice & Stores," *circa* 1780. These records are in the Royal Artillery Institution Library, Woolwich. Other records may exist which show the heavier calibres were tested in 1779.

37 RAI, "Experiments Woolwich 1778-1779," 6 July and 12 Aug. 1779.

38 At the National Maritime Museum, Greenwich, there is a 12-pounder carronade, 2 feet 8 inches long, dated 1805.

39 RAI, Richard Bogue, "Light 6 Pounder and Heavy Exercise," "A table containing the Weight & Length of Iron Guns & Carronades," pp. 139-40. It is quite possible Bogue is in error or has copied an old table. Adye (1813), op. cit., p. 88, except for an obvious typographical error, lists the calibres in the 1800 column.

40 RAI, Lefroy Papers, Miscellaneous, Vol. I, "Memorandum on the Recoil of Naval Ordnance," Woolwich, 3 Sept. (circa 1830), p. 97.

41 Robert Wilkinson-Latham, *British Artillery on Land and Sea, 1790-1820* (Newton Abbot: David & Charles, 1973), pp. 18-19. A drawing is reproduced entitled "32 Pounder Carronade fitting agreeably to General Bentham's directions on board of a River Barge at Woolwich July 1796," but the piece does not resemble a carronade but rather a short gun, although the carriage seems to be based on the carronade principle.

42 Blackmore, op. cit., p. 83, Plate 44.

43 National Maritime Museum, "9 Pounder Gun sic № 719 Dated 1826," Neg. 3209.

44 Hector Straith, *A Treatise on Fortification, (deduced from established principles); with a Memoire on Artillery* (London: W.H. Allen and Co., 1841), p. 84.

Mortars

1 Blackmore, op. cit., p. 236.

2 *The Gentleman's Dictionary* (1705), cited in ibid., pp. 235-6.

3 Blackmore, op. cit., p. 236.

4 RAI, James, op. cit., p. 27. He recorded the weight of 2 qr. 1/2-lb. There are dates in the book as late as 1725.

5 Kaestlin, op. cit., p. 13, II/54-5.

6 Blackmore, op. cit., p. 98; RAI, Glegg, op. cit., p. 119; RAI, Adye (1766), op. cit., pp 27-8; Muller (1780), op. cit., p. 68; Kaestlin, op. cit., p. 13, II/54-5.

7 Smith, op. cit., p. 309; *Aide-Mémoire* (1850), op. cit., Vol. 2, p. 515.

8 RAI, Glegg, op. cit., p. 119; Rudyerd, op. cit., Plate 19; Boxer, *Diagrams of Guns*, Plate XXXIX.

9 RAI, Glegg, op.cit., p. 119; Rudyerd, op. cit., Plate 19.

10 Adye (1813), op. cit., p. 260 states the length to be 1 foot 1-1/2-inches, but there are at the Tower of London cohorns of 1814, 1815, and 1819 with lengths of 1 foot 0.5 inch, 1 foot 0.75 inch, and 1 foot 1 inch respectively. Blackmore,

op. cit., pp. 103-4.

11 RAI, Glegg, op. cit., p. 119; Rudyerd, op. cit., Plate 19. The conical chamber was, more precisely, the frustum of a core terminated by a semi-hemisphere the diameter of which was the least diameter of the chamber.

12 Blackmore, op. cit., p. 231.

13 Ibid., p. 103; RAI, Collected Military Papers, Vol. 2, "Weight and Value of Brass Mortars, Howitzer, & Guns, with their Beds and Carriages: — Upon the old Construction." While this document gives no details of dimensions or construcion, it does imply that there was a "new" construction, which could possibly include a Gomer chamber. Indeed it is possible that the Gomer chamber, increased diameter, and increased length, in other words the Coehorn shown in the Boxer diagram, circa 1850, were inaugurated about 1795.

14 RAI, James, op. cit., p. 27; Blackmore, op. cit., p. 236.

15 Blackmore, op. cit., p. 236.

16 Kaestlin, op. cit., p. 12, II/35-6.

17 RAI, Glegg, op. cit., p. 119; cf. RAI, Adye (1766), pp. 27-8 and Muller (1780), p. 68; Kaestlin, op. cit., p. 12, II/35-6.

18 Smith, op. cit., p. 309; *Aide-Mémoire* (1850), op. cit., Vol. 2, p. 515.

19 RAI, James, op. cit. p. 27.

20 RAI, Glegg, p. 119; RAI, Adye (1766), op. cit., pp. 27-8; Blackmore, op. cit., pp. 100-1, 103, 107-8.

21 RAI, Glegg, op. cit., p. 119; Rudyerd, op. cit., Plate 18; RAI, Boxer, *Diagrams of Guns*, Plate XXXVIII.

22 RAI, James, op. cit., p. 27; RAI, Glegg, op. cit., p. 119; Smith, op. cit., p. 309; Rudyerd, op. cit., Plate 18.

23 Adye (1801), op. cit., p. 159 and (1813), op. cit., p. 260; Blackmore, pp. 100, 101, 103. The mortars are dated 1800, 1807 (2), and 1811.

24 Spearman (1828), op. cit. p. 304, says 15.104 inches; Boxer, *Diagrams of Guns*, Plate XXXVIII, says 15.1 inches.

25 Blackmore, p. 107.

26 Spearman (1828), p. 304.

27 RAI, James, op. cit., p. 27.

28 RAI, Glegg, op. cit., p. 119; Adye (1766), pp. 27-8; Muller, op. cit., p. 67; Smith, op. cit., p. 187.

29 Smith, p. 309.

30 Rudyerd, op. cit., Plate 17.

31 Adye (1801), p. 159 and (1813), p. 260.

32 Blackmore, op. cit., pp. 100-1.

33 RMC, Mould, op. cit., p. 319; Griffiths, op. cit. (1839), p. 52 and (1859), p. 63.

34 Straith, [1841], op. cit., (London: Allen & Co., 1841), Plate 2, Fig. 13.

35 Blackmore, op. cit., p. 108. The complete marking on the end of the right trunnion is R.G.F. Nº 1 W D.

36 Blackmore, op. cit., pp. 235-6.

37 RAI, James, op. cit., p. 27. Weight, 9 cwt., 3 qr., 27-1/2-lb.

38 RAI, Glegg, op. cit. p. 119. These dimensions are more or less duplicated in Muller (1780), op. cit., p. 67; Adye (1766), pp. 27-8; Smith, op. cit., p. 187.

39 Smith, op. cit., p. 309.

40 RAI, "Artillery Experiments, 1770-1; 1773," unpaginated; RAI, "Artillery Practice & Store," *circa* 1780, pp. 8, 34; Lefroy, "Note on Mortar Practice," *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 2 (1861), p. 16; Walton, op. cit., unpaginated.

41 Rudyerd, op. cit., Plate 16.

42 Adye (1801), p. 159 and (1813), p. 260.

43 Aide-Mémoire (1852), *op. cit.*, Vol. 3, p. 521.

44 RAI, "Collected Military Papers," Vol. 2, "Weight and Value of Brass Mortars, Howitzers, & Guns, with their Beds and Carriages: — Upon the old Construction," very late 1795 or early 1796, p. 231. RMC, Mould, op. cit., p. 319, in 1825 noted a 10-inch brass mortar of 11 3/4 cwt. which he said was obsolete. He may have erred in copying the weight.

45 Griffiths (1839), op. cit., p. 52, (1847), p. 70 and (1859), p. 63. Douglas, op. cit. (1860), p. 605, in a list dated 1847 cited the 10-inch brass mortar at the same length but 1/2 cwt. heavier.

46 Blackmore, op. cit., p. 235; RAI, James, op. cit., p. 27.

47 RAI, Glegg, op. cit., p. 119; Cf. Muller, op. cit., p. 67; RAI, Adye (1766), pp. 27-8; Smith, op. cit., p. 187.

48 Smith, op. cit., p. 309.

49 RAI, "Artillery Experiments, 1770-1; 1773," unpaginated; RAI, "Artillery Practice & Stores," *circa* 1780, p. 34; RAI, Walton, op. cit., unpaginated; Padfield, op. cit., p. 106, illustration of a gunner's rule, circa 1780.

50 Rudyerd, op. cit., Plate 15.

51 RAI, Adye (1766), opposite p. 26.

52 Adye (1801), p. 159 and (1813), p. 260; RAI, Shuttleworth Drawings.

53 RMC, Mould, op. cit., p. 319.

54 Blackmore, op. cit., p. 235.

55 RAI, Glegg, op. cit., p. 120; cf. RAI, Adye (1766), op. cit., pp. 29-30; Muller, (1780), op. cit., pp. 68-9.

56 Smith, op. cit., p. 309.

57 Rudyerd, op. cit., Plate 14.

58 Adye (1813), op. cit., p. 159.

59 Blackmore, op. cit., p. 235.

60 Ibid., pp. 97-8. Wt. 81 cwt. 2 qr. 24 lb.

61 RAI, Glegg, op. cit., p. 120; Muller (1780), op. cit., Plate II, Fig. 6, pp. 68-9; RAI, Adye (1766), op. cit., opposite p. 26, pp. 29-30.

62 Smith, op. cit., p. 309.

63 Adye (1813), op. cit., p. 260. Length 5 ft. 3 in., wt. 82 cwt. 0 qr. 8 lb.

64 Cited in Adrian B. Caruana, "Iron Mortars in 1812," *The Canadian Journal: Arms Collecting*, Vol. 25, No. 4 (Nov. 1987), pp. 127-8.

65 Ibid., pp. 127-8.

66 Ibid., p. 127. Caruana provides a drawing "according to the construction and dimensions given by Samuel Parlby."

67 Ibid., p. 127; RMC, Mould, op. cit., p. 100; RAI, Boxer, *Diagrams of Guns*, Plate XXXVI. The only difference between Mould's diagram is 1-1/2 inch shorter, thus making the total length 22 inches.

68 RMC, Noble, op. cit., p. 73 citing a list of 1847; RAI, Boxer, *Diagrams of Guns*, Plate XXXVII.

69 RAI, Report on Artillery 1854, "Abstract of Recommendations and Observations...for Coast Batteries...1853."

70 PRO, WO33/7, "Report of the Committee on Ordnance," 1859, pp. 3, 8.

71 Lefroy (1867), op. cit., p. 71; Owen and Porter, op. cit., p. 66.

72 Owen and Porter, op. cit., p. 65.

73 Caruana, "Iron Mortars in 1812," op. cit., p. 127-8.

74 Ibid., p. 128; RMC, Mould, op. cit., pp. 100, 319; RAI, Boxer, *Diagrams of Guns*, Plate XXXIV. Mould gave the length at 2 feet 3.5 inches.

75 RMC, Noble, op. cit., p. 73 citing a return of 1847; RAI, Boxer, *Diagrams of Guns*, Plate XXXV.

76 PRO, WO33/7, "Report of the Committee on Ordnance," 1859, p. 3; Miller, op.

cit., p. 345.
77 Owen and Porter, op. cit., p. 65.
78 Caruana, "Iron Mortars in 1812," op. cit., pp. 126-8.
79 Blackmore, op. cit., pp. 104-5. Note that the weights of the Tower mortars are closer to those of Parlby's mortar of 3 feet 8.6875 inches.
80 RMC, Mould, op. cit., pp. 100, 319; Blackmore, op. cit., pp. 102-3; Caruana, "Iron Mortars in 1812," op. cit., pp. 127-8.
81 RAI, Boxer, Diagrams of Guns, Plate XXXIII.
82 Miller, op. cit., p. 342.
83 Owen and Porter, p. 65.
84 Miller, op. cit., p. 344.
85 Fort Malden N.H.P., Adye, Notebook, *circa* 1800.
86 Caruana, "Iron Mortars in 1812," op. cit., pp. 125-7.
87 Parks, Quebec Region, Quebec City, rue des Remparts, two 10-inch iron sea service mortars marked on the left trunnions 57854/CARRON/1798 and 57869/CARRON/1798 and on the breech 47-2-14/N° 12 and 47-3-4/N° 14. Both have the broad arrow cut into the breech. The first measured 4 feet 7-2/16 inches and the second 4 feet 6-15/16 inches in length.
88 Parks, Quebec Region, Quebec City, rue des Remparts, 10-inch iron sea service mortar marked on the left trunnion 81353/CARRON/1813 and on the breech 52-0-13 and a broad arrow.
89 RMC, Mould, op. cit., p. 101.
90 Miller, op. cit., p. 345; Owen and Porter, op. cit., p. 65.
91 Spearman (1828), op. cit., p. 304.
92 RAI, Boxer, Diagrams of Guns, Plate XXXII.
93 Parks, Quebec Region, Quebec City, rue des Remparts, 10-inch iron sea service mortar marked on right trunnion 2, on left trunnion WC°, and on breech 52-1-18/1855 and the broad arrow.
94 There also may have been a lighter model of the same length but weighing 41 or 42 cwt. See RMC, Noble, op. cit., p. 73 citing a list of 1847; Griffiths (1939), op. cit., p. 52, (1847), p. 70 and (1859), p. 63.
95 Fort Malden N.H.P., Adye, Notebook, *circa* 1800.
96 Caruana, "Iron Mortars in 1812," op. cit., p. 126.
97 Ibid., p. 126, citing the notebook of a student, J. Cockburn in 1827; Miller, op. cit., p. 340. Mortars of this weight, cast in 1813 and 1814, were used at the bombardment of Sweaborg in the Baltic in Aug. 1855. See "Reports on 13-Inch Sea Service Mortars," Minutes of Proceedings of the Royal Artillery Institution, Vol. I (1858), p. 445.
98 RMC, Mould, p. 101.
99 RAI, Boxer, Diagrams of Guns, Plate XXXI.
100 Spearman (1828), op. cit. p. 304.
101 RAI, Boxer, Diagrams of Guns, Plate XXXI.
102 Miller, op. cit., p. 342.
103 "Reports on 13-Inch Sea Service Mortars," Minutes of Proceedings of the Royal Artillery Institution, Vol. I (1858), pp. 443-56.
104 Miller, op. cit., p. 340. Owen and Porter, op. cit., p. 65 say that it was introduced in 1857.
105 Owen and Porter, op. cit., p. 65.

Howitzers

1 Hughes, Smooth-bore, op. cit., p. 39.
2 Owen and Porter, op. cit., p. 65.
3 Aide Memoire (1850), op cit., Vol. 2, p. 251.

4 Smith, *op. cit.*, p. 302.

5 RAI, "Artillery Experiments, 1770-1; 1773," unpaginated; RAI, "Artillery Practice & Stores," *circa* 1780, p. 4; RAI, Walton, op. cit., unpaginated; Padfield, op. cit., "Gunner's Rule," *circa* 1780, p. 106; Rudyerd, op. cit., Plate 12.

6 Kaestlin, op. cit., p. 15. According to the note in the catalogue this model was introduced in 1795 and last cast in 1859.

7 RAI, Shuttleworth Drawings, "Coehorn Howitzer," Feb. 1819.

8 RMC, Mould, op. cit., p. 318; Spearman (1828), op. cit., p. 263.

9 RAI, Strange, op cit., unpaginated; RMC, Noble, op. cit., unpaginated. These drawings are almost identical. RAI, Boxer, op. cit., Plate XXXIX.

10 *Aide-Mémoire* (1846), op. cit., Vol. I, pp. 58-9.

11 Owen and Porter, op. cit., Plate 1.

12 Ibid., p. 65.

13 RAI, Glegg, op. cit., p. 139. On page 142, in 1756, he mentions specifically a Royal howitzer of 4 cwt. 27 lbs.

14 Smith, op. cit., p. 302.

15 RAI, "Artillery Experiments, 1770-1; 1773," unpaginated; RAI, "Artillery Practice & Stores" (Part I), p. 28, (Part II), p. 36; RAI, "Experiments Landguard Fort 1780," unpaginated; RAI, Walton, op. cit., 1780-90, unpaginated; Padfield, op. cit., "Gunner's Rule," *circa* 1780, p. 106.

16 Kaestlin, op. cit., p. 15, II/68-9.

17 Rudyerd, op. cit., Plate 12. There are also less complete specifications contained in RAI, Walton, op. cit., unpaginated, which are almost the same as Rudyerd's.

18 RAI, Bogue, op. cit., unpaginated.

19 RAI, "Experiments in Gunnery — carried out at Woolwich 1819 to 1826," pp. 1-56; RMC, Mould, op. cit., p. 318.

20 RAI, Shuttleworth drawings, "5 1/2 inch Howitzers," circa 1820.

21 Kaestlin, op. cit., p. 16.

22 Hughes, *Smooth-Bore*, op. cit., p. 39.

23 Kaestlin, op. cit., p. 16, II/78.

24 Adye (1801), op. cit., p. 128 and (1813), p. 222.

25 RAI, Frazer, "Practice," Vol. I, 1810-11, p. 154, "Lengths & Weights of ordnance used at the Practice at Sutton in 1811." Weights, 9 cwt. 2 qr. 25 lb. and 9 cwt. 2 qr. 7 lb.

26 RAI, "Experiments in Gunnery — carried out at Woolwich 1819 to 1826," pp. 1-56. Weight 9 cwt. 3 qr. 13 lbs.

27 RMC, Mould, op. cit., p. 318; Spearman (1828), op. cit., p. 263; Griffiths (1839), op. cit., p. 52; Straith (1841), op. cit., p. 93.

28 Griffiths (1847), op. cit., p. 70.

29 Spearman (1828), op. cit., p. 263; Straith (1841), op. cit., p. 93.

30 RMC, Mould, op. cit., p. 318.

31 Kaestlin, op. cit., p. 11.

32 RAI, Borgard, Practtis of Artillery, *circa* 1714, unpaginated.

33 RAI, James, op. cit., p. 27; Hughes, *Smooth-Bore*, op. cit., p. 39, says it was first cast in 1719 but gives no source.

34 Hughes, *Smooth Bore*, op. cit., p. 39; Kaestlin, op. cit., p. 16.

35 RAI, Glegg, op. cit., p. 122.

36 RAI, Portfolio, *circa* 1735.

37 Muller (1780), op. cit., pp. 69-70; RAI, Adye (1766), op. cit., pp. 31-2; Smith, op. cit., p. 132.

38 Kaestlin, op. cit., p. 14.

39 Rudyerd, op. cit., Plate 12.

40 Smith, op. cit., p. 302.

41 RAI, "Artillery Experiments, 1770-1; 1773," unpaginated; RAI, "Artillery Practice & Stores," (Part 1), p. 21 (Part 2), p. 36; RAI, "Experiments Woolwich 1778-1779," unpaginated; RAI, "Experiments Landguard Fort 1780," unpaginated; RAI, Walton, op. cit., unpaginated; Padfield, op. cit., "Gunner's Rule," *circa* 1780, p. 106.

42 Keastlin, op. cit., p. 16; RAI, Shuttleworth drawings, "8 Inch Brass Howitzer," May 1819.

43 RMC, Mould, op. cit., p. 318.

44 *Aide-Mémoire* (1850), op. cit., Vol. 2, p. 251.

45 Hughes, *Smooth Bore*, op. cit., p. 39 citing Sir John James, *Journal of the Seiges in Spain*. According to Hughes, Jones "...suggests that these howitzers failed more from age and wear than from the softening of the metal which affected the brass guns." This statement suggests that the howitzers used were not the pattern of the 1814 example. Perhaps, then, the latter pattern was developed as a result of the failure of the older howitzers, and thus we must date its introduction much later than the 1790s, say 1813 or 1814.

46 Kaestlin, op. cit., p. 16.

47 Hughes, *Smooth-Bore*, op. cit., p. 39; see also Kaestlin, op. cit., p. 16.

48 RAI, Glegg, op. cit., p. 122. These dimensions match those given by Muller (1780), op. cit., pp. 69-70; RAI, Adye, op. cit., pp. 31-2; Smith, op. cit., p. 132.

49 Muller (1780), op. cit., p. 83.

50 RAI, "Artillery Experiments, 1770-1; 1773," unpaginated; RAI, "Experiments Woolwich 1778-1779," unpaginated; RAI, "Artillery Practice & Stores," *circa* 1780, (Part I), p. 20, (Part II), p. 36; RAI, "Experiment Landguard Fort 1780," unpaginated; RAI, Walton, op. cit., unpaginated; Padfield, op. cit., p. 106, "Gunner's Rule," *circa* 1780. Its length was reported at 3 feet 11, 11.2, 11.5 inches and an even 4 feet.

51 Rudyerd, op. cit., Plate 12.

52 Hughes, *Smooth-Bore*, op. cit., p. 39.

53 RAI, Frazer, "Practice," 1810-11, Vol. I, pp. 149, 154.

54 Kaestlin, *op. cit.*, p. 16.

55 RMC, Mould, op. cit., p. 318.

56 Miller, op. cit., p. 178 says 1820; Kaestlin, op. cit., p. 16 and Hughes, *Smooth-Bore*, op. cit., p. 39, presumably based on Kaestlin, says 1822. RAI, "Experiments in Gunnery — carried out at Woolwich 1819 to 1826," pp. 1-56 and "Practice with Howitzers of M. Gen.^{l} Millars Construction, Woolwich May to June, 1819," pp. 56-60; Adye (1827), op. cit., "Ranges with common Shells from a 24 and 12-Pounder Brass Howitzer, Nov. 1819," p. 217.

57 RMC, Mould, op. cit., p. 318; Miller, op. cit., p. 178.

58 Spearman (1828), op. cit., p. 263; RAI, Boxer, *Diagrams of Guns*, Plate XXVIII; *Aide-Mémoire* (1853), op. cit., Vol. I, pp. 262-3. There are times when it is stated at 4 feet 9 inches or 4 feet 9 1/2 inches.

59 Griffiths (1839), op. cit., p. 52 is the first manual to record this calibre.

60 Spearman (1828), op. cit., p. 263; RAI, Boxer, op. cit., Plate XXVIII; *Aide-Mémoire* (1846), op. cit., Vol. I, pp. 58-9 and (1853), Vol. I, pp. 262-3. There are minor variations in the dimensions given in the two editions of the *Aide-Mémoire*.

61 Kaestlin, op. cit., p. 16; Miller, op. cit., p. 178.

62 Kaestlin, op. cit., p. 16, II/85.

63 Douglas, op. cit. (1860), p. 604.

64 Kaestlin, op. cit., p. 15, II/71.

65 Douglas, op. cit. (1860), p. 604, citing a list dated 1848.

66 A partial list of dimensions is given in PRO, Supply Department Records, Supp. 5, 76, "Notes on Manufacturers of the Royal Carriage Department," p. 30, "Names, Weights, and Principal Dimensions of Ordnance used in the British Service November 1864."

67 Miller, op. cit. p. 183, says at the same time as the 12-pounder, i.e. 1820; Hughes, Smooth-Bore, op. cit., p. 39, says 1822; RAI, "Experiments in Gunnery – carried out at Woolwich 1819 to 1826," pp. 1-56 and "Practice with Howitzers of M. Gen^{l}: Millars Construction Woolwich May to June, 1819," pp. 56-60; Adye (1827), op. cit., "Ranges with common Shells from a 24 and 12-Pounder Brass Howitzer, Nov. 1819," p. 217.

68 RMC, Mould, op. cit., p. 318; Miller, op. cit., p. 183.

69 Spearman, (1828), op. cit., p. 263; RAI, Boxer, Diagrams of Guns, Plate XXVII; Aide-Mémoire, op. cit. (1853), Vol. I, pp. 262-3. There are times when it is stated at 4 feet 8 inches or 4 feet 9 inches.

70 Griffiths (1839), op. cit., p. 52 is the first manual to record this calibre.

71 Spearman (1828), op. cit., p. 263.

72 RAI, Boxer, Diagrams of Guns, Plate XXVII; Aide-Mémoire (1853), op. cit., Vol. I, pp. 262-3. The 1845 edition, Vol. I, pp. 58-9, gave different figures, length 8.76 inches, tapering to 4.25 inches.

73 Miller, op. cit., p. 183.

74 RAI, Strange, op. cit., unpaginated, diagram of 24 P^{R} Brass Howitzer. "For sea service there would be no vent field astragal and fillets & the ring at the second reinforce would be sloped off as in the iron howitzer."

75 Douglas (1860), op. cit., p. 604 citing a list dated 1848; information attched to howitzers at National Maritime Museum, Greenwich.

76 Straith (1841), op. cit., p. 20; Hughes, Smooth-bore, op. cit., p. 39.

77 Miller, op. cit., p. 188, says "about 1840;" Keastlin, op. cit., p. 16, and Hughes, Smooth-Bore, op. cit., p. 39, presumably following Kaestlin say 1841.

78 Miller, op. cit., p. 188.

79 Kaestlin, op. cit., p. 16.

80 RAI, Boxer, Diagrams of Guns, Plate XXVI; Aide-Mémoire (1853), op. cit., Vol. I, pp. 262-3.

81 Kaestlin, op. cit., p. 16, II/86.

82 Miller, op. cit., pp. 332-3.

83 RAI, Frazer, "Practice," Vol. I, p. 119, practice of 22 Nov. 1810.

84 Kaestlin, op. cit., p. 37.

85 Miller, op. cit., pp. 332-3.

86 RAI, Boxer, Diagrams of Guns, Plate XXV.

87 RAI, Shuttleworth drawings, "Elevation of a Traversing Platform with Pivot in Centre," June 1819. On the platform is what appears to be an iron 5-1/2-inch howitzer.

88 RMC, Mould, op. cit., p. 319; Adye (1827), op. cit., p. 213.

89 Griffiths (1839), op. cit., p. 52, (1847), p. 70 and (1852), p. 60.

90 RMC, Mould, op. cit. p. 319.

91 RMC, Noble, op. cit., p. 73; Douglas (1860), op. cit., p. 605, both citing a list of 1847.

92 Aide-Mémoire (1846), op. cit., Vol. I, pp. 56-7; RAI, Boxer, Diagrams of Guns, Plate XXV.

93 There was also a discrepancy in bore length, Boxer's being longer. It is likely that the Aide-Mémoire was stating the length exclusive of the chamber, at least that would be the measurement on Boxer's diagram.

94 Miller, op. cit., p. 333.

95 Lefroy (1867), op. cit., p. 75; Owen and Porter, op. cit., p. 66.

96 RAI, "Experiments in Gunnery — carried out at Woolwich 1819 to 1826," pp. 1-60.

97 RAI, "Report of the Committee of Officers, ... authorised ... under Date of the 3rd of December 1819," p. 123. See also Minutes of Proceedings of the Royal Artillery Institution, Vol. 1 (1858), p. 237, that reproduces the report with a note by the editor "The pieces referred to are those now in the service, and which were introduced by Colonel Millar, in 1820."

98 Hughes, Smooth-Bore, op. cit., p. 39; Miller, op. cit., pp. 328-31.

99 RMC, Mould, op. cit., p. 319.

100 RMC, Mould, ibid., p. 99; RAI, Boxer, Diagrams of Guns, Plates XXII, XXIII.

101 RMC, Mould, op. cit., p. 99; Aide-Mémoire (1846), op. cit., Vol. I, pp. 56-7, and (1853), Vol. I, pp. 60-1; RAI, Boxer, Diagrams of Guns, Plates XXII, XXIII.

102 Minutes of Proceedings of the Royal Artillery Institution, Vol. I (1858), "A Synoptical Table of the Deal Practice carried on in the Year 1839."

103

8-inch

	1828	**1853**
length of bore	46.8 in.	45.75 in.
chamber: length	9.5 in.	9.5 in.
greatest diameter	8. in.	8. in
least diameter	6. in	6. in

10-inch

	1828	**1853**
length of bore	58.75 in.	57.21 in.
chamber: length	11.25 in.	11.25 in.
greatest distance	10. in.	10. in.
least diameter	7.5	7.5

Cf. Spearman (1828), op. cit., p. 263; RAI, Boxer, Diagrams of Guns, Plates XXII, XVIII. In 1853, the Aide-Mémoire, Vol. I, pp. 60-1 gave the least diameter of the chamber of the 8-inch howitzer as 6.14 inches and of the 10-inch as 7.47 inches. The Aide-Mémoire also gave a slightly different bore length for the 10-inch howitzer in 1845: 58.46 inches.

104 Lefroy (1867), op. cit., p.72.

105 Owen and Porter, op. cit., p. 65.

Carriages and Limbers

1 Miller, op. cit., p. 89.

2 RAI, James, op. cit., pp. 4-5, "Dimentions of the Bodies of Standing Carriages, Plank Wheels, and Extrees according to the New Regulations, 1721" and "Draught of a 42 Poundr. Gunn and Standing Carriage to an 1/2 Inch scale."

3 Ibid., p. 19; Adrian B. Caruana, "Albert Borgard and British Artillery of 1675-1725," The Canadian Journal; Arms Collecting, Vol. 20, No. 3 (Aug. 1982), p. 80.

4 Muller (1780), op. cit., pp. 96-7; cf. RAI, Adye (1766), op. cit., p. 40; Smith, op. cit., p. 51.

5 Muller (1780), op. cit., pp. 95-9; cf. Rees, op. cit., Vol. 6, "Carriage" for a very similar statement of this formula.

6 Rudyerd, op. cit., Plates 45-9.

7 Muller (1780), op. cit., p. 96.

8 Ibid., p. 98.

9 Ibid., p. 99.

10 The labelling of the various drawings of aspects of the axletrees has been scrambled, e.g. what is entitled "side of front Axle-tree" is clearly "bottom of hind Axle-tree." Rudyerd, op. cit., Plate 46.

11 Ibid., Plates 45-9.

12 Ibid., Plate 47. DND, Fitzhugh, op. cit., p. 159, in 1845 said that the transom bolt was riveted and RAI, Richardson, op. cit., in 1859 indicated that the both bolts were riveted.

13 RAI, Shuttleworth Drawings, "Heavy 24 Pounder," circa 1820 and "Elevation of a Traversing Platform with Pivot in the Centre," 1819, do not show capsquares. Cf. Aide-Mémoire (1853), op. cit., Vol. I, "Carriage," Plate I, "32, 24, & 18 Pounder Garrison Carriage Wood." RAI, Richardson, op. cit.; Owen, Elementary, op cit., p. 66.

14 RAI, Shuttleworth Drawings, "Heavy 24 Pounder," circa 1820; DND, Fitzhugh, op. cit., pp. 159-60; W. Kemmis, Treatise on Military Carriages and Other Manufactures of The Royal Carriage Department. London: HMSO, 1874, p. 95; PRO, "Notes on the Manufacture of the Royal Carriage Department," p. 16, is at variance, saying the front bolt was riveted.

15 DND, Fitzhugh, op. cit., pp. 1590-60.

16 PRO, "Notes on the Manufactures of the Royal Carriage Department," p. 16.

17 NA, RG8, I, Vol. 384, p. 206.

18 RAI, Shuttleworth Drawings, "Elevation of a Traversing Platform with Pivot in the Centre," 1819.

19 DND, Fitzhugh, op. cit., p. 160.

20 RAI, Richardson, op. cit.; Owen, Elementary, p. 66.

21 RAI, Richardson, op. cit.

22 Quarterly List of Changes, Approved 10 Aug. 1860; RAI, Royal Carriage Department [henceforth RCD], Plate 75, September 1870, "Smith's Elevating Screw."

23 PRO, "Notes on the Manufactures of the Royal Carriage Department," op. cit., p. 17; Owen, Elementary, op. cit., Plate 10, "Garrison Carriage 8 Inch Common Standing."

24 Miller, op. cit., p. 385.

25 PRO, "Notes on the Manufactures...," op. cit., p. 17; Kemmis, op. cit., p. 95.

26 Quarterly List of Changes, 963, Approved 19 July 1864.

27 Royal Canadian Military Institute [henceforth RCMI], RCD, Plate 62, "Garrison Carriages," May 1870 and Plate 63, "Garrison Standing Carriage for 32 Pr. 56 or 58 CWT.," June 1870.

28 Blackmore, op. cit., p. 176. He also refers to a three wheel carriage, patented by Louis de Villers in 1753 (Pat. No. 683), which was mainly adopted by the East India Companies.

29 Ibid., p. 176; S.J. Gooding, "The Traversing Platform," The Canadian Journal of Arms Collecting, Vol. 4, No. 3 (Aug. 1966), p. 107. No specific references were given. Adye (1813), op. cit., p. 93.

30 Aide-Mémoire (1853), op. cit., Vol. I, p. 290.

31 Miller, op. cit., p. 88.

32 Aide-Mémoire (1846), op. cit., Vol. I, "Carriage," Plate I. The plate is dated 1844.

33 Hector Straith, Plates for Major Straith's Treatise on Fortification and Artillery (London: Allen and Co., 1852), Plate XII, "Iron Garrison Carriage."

34 Based on drawings in ibid., and Aide-Mémoire (1846), op. cit., Vol. I, "Carriages," Plate I, and carriages owned by Parks.

35 Griffiths (1859), op. cit., p. 68.

36 RCMI, RCD, Plate 62, "Garrison Carriages," May 1870.

37 PRO, "Notes on the Manufactures...," op. cit., p. 17; Kemmis, op. cit., pp. 95-6; RAI, RCD, Plate 75, "Smith's Elevating Screw," Sept. 1870.

38 Quarterly List of Changes, I, approved 25 Feb. 1860 and 907, approved 27 April

1864.

39 PRO, "Notes on the Manufactures...," op. cit., p. 31.

40 Aide-Mémoire (1846), Vol. I, Defence of Costs, Plate 1, "Dwarf Wooden Traversing Platform," approved 1 April 1846; RAI, Strange, Drawings on Artillery, circa 1851, "56 Pr. 11 Pt. 98 cwt. on a Dwarf Traversing Platform."

41 This description is based in part on the drawings but also on what was known about working the carriage in the 1860s, which cannot have differed much from the 1840s.

42 Quarterly List of Changes, 962, approved 23 Aug. 1864.

43 Ibid., 681, approved 17 Oct. 1862.

44 Kemmis, op. cit., p. 98.

45 Quarterly List of Changes, 681, approved 17 Oct. 1862.

46 Miller, op. cit., pp. 270-1; PRO, "Notes on the Manufactures...," op. cit., pp. 17-18; Kemmis, op. cit., p. 96.

47 Muller (1780), op. cit., p. 191; RAI, Adye (1766), op. cit., pp. 60-1.

48 Muller (1780), op. cit., p. 191; cf. RAI, Adye (1766), op. cit., p. 60.

49 Smith, op. cit., p. 28.

50 Muller (1780), op. cit., p. 123.

51 Rudyerd (op. cit.), Plate 53.

52 RAI, Shuttleworth Drawings, "13 inch Mortar," circa 1820 and "8 Inch Brass Mortar," 1820.

53 Adye (1801), op. cit., p. 35 and (1813), op. cit., p. 63.

54 Isaac Landmann, The Principles of Artillery, reduced into Questions and Answers, for the Use of the Royal Military Academy at Woolwich (London: Egerton, 1808), p. 27.

55 RMC, Mould, op. cit., p. 327.

56 Fort Malden National Historic Park, Adye, Notebook, circa 1800, "General Construction of Land Service Mortar Beds. Colonel Blomefield's."

57 Aide-Mémoire (1846), op. cit., "Carriage," Plate 3, "13 Inch Land Service Mortar Bed," 1844.

58 Ibid., "10 Inch Land Service Mortar Bed (New Pattern)," 1844.

59 Fort Malden NHP, Adye, Notebook, circa 1800, "General Construction...; Adye (1801), op. cit., p. 35 and (1813), op. cit., p. 63; RMC, Mould, op. cit., p. 327.

60 Spearman (1828), op. cit., p. 308.

61 Griffiths (1840), op. cit., p. 70, (1847), p. 78, (1852), p. 68, (1859), p. 71, (1862), p. 74.

62 Aide-Mémoire (1853), op. cit., Vol. I, "Carriage," Plate 3, "10 Inch Land Service Mortar Bed," 1852.

63 National Maritime Museum, Greenwich. The 10-inch mortar is dated 1856; there is no date on the bed.

64 Quarterly List of Changes, 15, "Travelling carriage for 8-inch mortar for naval service in China," approved 5 Dec. 1859.

65 Ibid., 214, "Carriages, travelling, for 8-inch and 10-inch mortars," approved 18 Dec. 1860, and 216, "Carriage, travelling, for the 13-inch mortars," approved 15 Feb. 1861.

66 RAI, RCD, Plate 48, "Travelling Carriage for an 8 Inch L.S. Mortar," June 1869, Plate 49, "Travelling Carriage for a 10 Inch L.S. Mortar," May 1869, Plate 50, "Travelling Carriage for 13 In. L.S. Mortar," July, 1869.

67 Quarterly List of Changes, 680, approved 2 Dec. 1862.

68 RAI, Adye (1766), pp. 60-2; Muller (1780), op. cit., pp. 119-20 and Plate XIV.

69 Adye (1801), op. cit., p. 35.

70 Blackmore, op. cit., p. 103 and Plate 72. The height given, 3.8 in., must be an error for 8.3 in.

71 Spearman (1828), op. cit., p. 308; Griffiths (1862), op. cit., p. 68.
72 *Aide-Mémoire* (1846) and (1853), op. cit., Vol. I, "Carriage," Plate 3, "5 1/2 Inch Mortar Bed," 1844 and 1852.
73 Muller (1780), op. cit., p. 108; cf. Adye (1766), p. 50.
74 Muller (1780), op. cit., p. 108.
75 RAI, Richardson, op. cit., unpaginated; Owen, *Elementary*, op. cit., p. 64.
76 RAI, Borgard, Tables, No. 36, "Dimensions, Weight and Value of Iron-work for Hind & Fore Wheels for Travelling-Carriages; according to the New Regulation by Colonel Albert Borgard in the Year 1719."
77 Muller (1780), op. cit., p. 107 and Plate IX.
78 Rudyerd, op. cit., Plates 28, 29; RMC, Mould, op. cit., p. 167.
79 RAI, Borgard, Tables, No. 36, "Dimensions, Weight and Value of Iron-work ... 1719."
80 Muller (1780), op. cit., p. 107; RAI, Adye (1766), p. 48; Smith, op. cit., p. 53; Rudyerd, op. cit., Plates 26, 32, 33.
81 RMC, Mould, op. cit., p. 167.
82 Griffiths (1839), op. cit., p. 53.
83 RAI, Borgard, Tables, No. 36, "Dimensions, Weight and Value ... 1719."
84 Muller (1780), op. cit., p. 107; RAI, Adye (1766), op. cit., p. 48; Smith, op. cit., p. 53.
85 Rudyerd, op. cit., Plates 23, 25, 26,35, 39.
86 Hughes, *Smooth-Bore*, op. cit., pp. 101-2; RMC, Mould, op. cit., p. 167.
87 Smith, op. cit., p. 193.
88 RAI, Borgard, Tables, No. 37, "Dimensions, Weight and Value of Iron-Work for Hind and Fore Wheels for Travelling-Carriages; according to the New Regulation by Colonel Albert Borgard in 1719"; Muller (1780), op. cit., p. 107; RAI, Adye (1766), op. cit., p. 48.
89 Adye (1813), op. cit., p. 301.
90 RMC, Mould, op. cit., p. 165.
91 Straith (1841), op. cit., p. 46; DND, Fitzhugh, op. cit., p. 158; Owen, *Elementary*, op. cit., p. 64.
92 Smith, op. cit., p. 34.
93 RMC, Mould, op. cit., p. 165.
94 DND, Fitzhugh, op. cit., p. 158; Owen, *Rough Notes*, op. cit., p. 47.
95 Adye (1801), op. cit., p. 57 and (1813), op. cit., pp. 390-1.
96 RMC, Mould, op. cit., pp. 168, 170; Spearman (1828), op. cit., pp. 425-6 and (1844), op. cit., "Wheel," unpaginated.
97 Miller, op. cit., p. 383; Owen, *Elementary*, p. 65; PRO, "Notes on the Manufacture ...," p. 29; Lefroy (1867), op. cit., pp. 147-8.
98 Muller, op. cit., Plate IX.
99 RAI, Borgard, Tables, No. 38, "Dimentions, Weight and Value of Iron Work for Hind and Fore Extrees, for Travelling Carriages; according to the New Regulation by Colonel Albert Borgard in the Year 1719;" Muller, op. cit., p. 118; RAI, Adye (1766), op. cit., p. 56; Rudyerd, op. cit., Plates 29, 30.
100 RAI, Borgard, Tables, No. 38, "Dimentions, Weight ... for ... Extrees ... 1719;" Rudyerd, op. cit., Plate 26; Landmann, *Principles*, op. cit., Plate 2.
101 Muller, op. cit., p. 109, Plate 106; Rudyerd, op. cit., Plate 26.
102 RAI, Borgard, Tables, No. 38. "Dimentions, Weight ... for ... Extrees ... 1719;" Muller, op. cit., p. 109, Plate IX; Rudyerd, op.cit., Plates 26, 28, 30.
103 Smith, op. cit., p. 132.
104 Rudyerd, op. cit., Plates 28, 29.
105 Adye (1801), op. cit., p. 56.
106 Adye (1813), p. 91.

107 RAI, "Report of a Select Committee...1820...," pp. 134-5.

108 RMC, Mould, op. cit., pp. 171-4.

109 Spearman (1828), op. cit., pp. 50-1 and (1844), op. cit., "Axletree," unpaginated.

110 Miller, op. cit., p. 384; Lefroy (1867), op. cit., pp. 148-9; PRO, "Notes on the Manufactures ...," p. 28.

111 DND, Fitzhugh, p. 151.

112 RAI, Richardson, op. cit., unpaginated; Owen, Rough Notes, pp. 44-5.

113 This generalized description is based on RAI, Borgard, Tables, No. 39, No. 40, No. 41, "Dimentions, Weight, and Value of Iron Work for Bodies of Travelling Carriages according to the New Regulation in 1719;" RAI, James, op. cit., p. 2, "Dimentions of the Bodies of Travelling Carriages according to the New Regulation 1719," pp. 10, 12, "Dimentions of Iron Works for Bodies of Travelling Carriages;" Muller (1780), op. cit., pp. 99-104, 106, Plates VI, VII, VIII; RAI, Adye (1766), op. cit., pp. 44-50; Smith, op. cit., pp. 52-3; Rudyerd, op. cit., Plates 20-2, 26 27, 32, 33, 37.

114 Muller (1780), op. cit., pp. 112-14, Plates X, XI; RAI, Adye (1766), op. cit., pp. 50-2; Smith, op. cit., p. 53, Plate VII.

115 Muller (1780), op. cit., p. 114; cf. Smith, op. cit., Plate VII.

116 Muller (1780), op. cit., p. 114.

117 Ibid.

118 Ibid.

119 Ibid.

120 Ibid. p. 115.

121 Caruana, Grasshoppers and Butterflies, op. cit.

122 RAI, "A particular account of the Alterations made in the Light 6 Por. Carriages in the Year 1776, by order of the Right Honourable Lord Visct. Townshend Master General of the Ordnance, &ca. — also the reasons for making them." These documents are published in Caruana, The Light 6-Pdr. Battalion Gun of 1776, op. cit., pp. 11-21. See Rudyerd, op. cit., Plates 38, 39 for a plan and elevation of the carriage.

123 Muller (1780), op. cit., p. 115; RAI, Adye (1766) op. cit., pp. 57-8.

124 RAI, James, op. cit., p. 11.

125 Ibid., p. 8.

126 Muller (1780), op. cit., pp. 115-16, Plate XII; RAI, Adye (1766), op. cit., pp. 57-9.

127 Aide-Mémoire (1846), op. cit., Vol. I, "Carriage," Plate 30; cf. RAI, RCD Photolithographs, Plate 1, "Mountain Service Carriages," 1867.

128 Adrian B. Caruana, "The Introduction of the Block Trail Carriage," The Canadian Journal: Arms Collecting, Vol. 18, No. 1 (Feb. 1980), p. 3; Hughes, Smooth-Bore, op. cit., pp. 67-8.

129 RAI, Defence of the Coast, "An Account of the Field Pieces which His Grace the Duke of Richmond ordered to be constructed in 1788" by William Congreve, pp. 180-1.

130 "An Account of the Proposals for the Management of the Heavy Three Pounders contrived by General Thomas Desaguliers for the Service of Cavalry, made by Captain William Congreve in the year 1779," quoted in Carauna, "The Introduction of the Block Trail Carriage," op. cit., p. 9.

131 Caruana, "The Introduction of the Block Trail Carriage," op.cit., pp. 3-7. This brief summary is based largely on Caruana's analysis. He also published many supporting documents, pp. 7-16.

132 Adye (1813), op. cit., p. 90.

133 Ibid., p. 390.

134 Donald E. Graves, "A Note on British Field Artillery Equipments of the War of

1812," *The Canadian Journal: Arms Collecting*, Vol. 20, No. 4 (Nov. 1982), pp. 128-9. Graves cites evidence that the bracket trail, along with block trail carriages, were being sent to Canada as late as 1812.

135 RAI, Shuttleworth Drawings, "Light Six Pounder" and "Plan of a Light Six Pounder," *circa* 1820; "Medium 12 Pounder," 1820.

136 *Aide-Mémoire* (1846), op. cit., Vol. I, "Carriage," Plates 19-22, 25, 26, 29, 30 and (1853), op. cit., Vol. I, "Carriage," Plates 8-9.

137 RAI, RCD, Photo-lithographs, Plates 1, 3, 13, 14, 15.

138 Block trail for 18-pdr. approved 23 Feb. 1859; for 32 and 24-pdrs., 31 March 1860; for 8-inch gun, 2 June 1860. *Quarterly List of Changes*, 14, approved 2 March 1860 and 98, approved 2 June 1860; RAI, RCD Photo-Lithographs, Plate 41, "Block Trail Carriage for 18 Pr. 38 Cwt. Gun," 1869, and Plate 42, "Block Trail Carriages; Details of Woodwork," 1869.

139 RAI, Borgard, Practtis of Artillery, *circa* 1714; RAI, Borgard, Tables, Nos. 39, 40, 41, "Dimentions, Weight and Value of Iron Work for Bodies of Travelling Carriages according to the New Regulation in 1719;" RAI, James, op. cit., p. 2, "Dimensions of the Bodies of Travelling Carriages according to the New Regulation 1719."

140 RAI, Adye (1766), pp. 65-7, Plate 11; Muller (1780), op. cit., p. 124, Plate XVII.

141 Smith, op. cit., p. 55.

142 Rudyerd, op. cit., Plate 50.

143 Adye (1813), op. cit., p. 90.

144 Hughes, *Smooth-Bore*, op. cit., pp. 39, 68.

145 RAI, Shuttleworth Drawings, "5 1/2 inch Howitzer" and "Plan of a 5 1/2 inch Howitzer," *circa* 1820.

146 RAI, RCD, Photo-lithographs, Plate 1, "Mountain Service Cariages," 1867 and Plate 4, "4 2/5 in Howitzer Carriage-Colonial Service," 1867.

147 Hughes, *Smooth-Bore*, op. cit., p. 68.

148 Straith, *Plans...* (1841), op. cit., Artillery Plate 2, "Elevation of General Miller's sic 24 Pounder, Howitzer & Carriage"; *Aide-Mémoire* (1846), op. cit., Vol. I, "Carriage," Plates 14, 15, Elevation and Plan of the 24 Pr. & 12 Pr. Howitzer Carriage, 1845.

149 *Aide-Mémoire* (1853), op. cit., Vol. I, "Carriage," Plates 10, 11, Elevation and Plan of the 24 Pr. Howitzer Carriage, 1852.

150 RAI, RCD, Photo-lithographs, Plate 16, "12 Pr. Howr. Field Carriage" (approved 17 April 1864), 1867 and Plate 17, "24 Pr. Howr. S.B. Field Carriage" (approved 27 April 1864), 1867.

151 *Aide-Mémoire* (1846), op. cit., Vol. I, "Carriage," Plates 12, 13, 32 Pounder Howitzer, Elevation and Plan, 1845; RAI, RCD, Photo-lithograph, Plate 18, "Field Carriage for 32 Pr. Brass Howitzer," 1867.

152 Miller, op. cit., p. 90.

153 RMC, Mould, op. cit., p. 327.

154 Straith, *Plans...* (1841), Artillery Plate 2; Straith (1846), op. cit., p. 588; Straith (1858), Artillery Plates I, II, III; *Aide-Mémoire* (1846), op. cit. Vol. I, pp. 215-16, and "Carriage," Plates 6-9; Miller, op. cit., p. 240; Owen, *Elementary*, p. 63 and Plate 8.

155 Adye (1813), p. 93.

156 RAI, Mould, op. cit., p. 327.

157 Miller, op. cit., pp. 328, 330.

158 Spearman (1828), op. cit., pp. 115-16 and (1844), "Car," unpaginated; *Aide-Mémoire* (1846), op. cit., Vol. I, "Carriage," Plate 4.

159 The dimensions of the illustration seem to match those given by Spearman in 1844. Spearman in 1828 and 1844 referred to "Trail-Bearing — (Cast Iron)."

160 Miller, op. cit., pp. 328, 330.

161 RAI, Shuttleworth Drawings, "Elevation of a Traversing Platform with Pivot in Centre," 1819; *Aide-Mémoire* (1846), Vol. I, op. cit., "Carriage," Plate 5, and (1853), Plate 2. The only difference in the two plates seems to be the head of the elevating screw — flat in 1846 and rounded in 1853.

162 Miller, op. cit., p. 332.

163 Griffiths (1852), op. cit., p. 67.

164 RAI, "Experiments Woolwich 1778-9," unpaginated; RAI, Pamphlet, *A Description of the New-Invented Gun called a Carronade; and its Uses* (Edinburgh, [1779]), p. 10.

165 See illustrations in ffoulkes, *Arms and Armaments...*, op. cit., Plate XIII; Padfield, op. cit., p. 104; Wilkinson-Latham, op. cit., p. 17; *Aide-Mémoire* (1846), op. cit., Vol. I, "Carriage," Plate 2, 1845; Boyd, op. cit., p. 247-8.

166 William Congreve, *An Elementary Treatise on the Mounting of Naval Ordnance* (London: Egerton and Wyatt, 1811), p. 37.

167 Boyd, op. cit., p. 248; *Aide-Mémoire* (1846), op. cit., "Carriage," Plate 2, 1845.

168 Cited by Wilkinson-Latham, op. cit., p. 18.

169 Padfield, op. cit., p. 104.

170 National Maritime Museum, Greenich, U.K., "A Brig of War's 12 Pr. Carronade," 1828, neg. 2417.

171 Ivan J. Saunders "A History of Martello Towers in the Defence of British North America, 1796-1871," *Canadian Historic Sites: Occasional Papers in Archaeology and History*, No. 15 (1976), p. 15; Sheila Sutcliffe, *Martello Towers* (Newton Abbot: David & Charles, 1972), pp. 56, 77.

172 Saunders, op. cit., pp. 22-37 passim.

173 Ibid., pp. 22, 24, 26, 35, 37, Plan, pp. 93-4.

174 This description is based mainly on *Aide-Mémoire* (1846), op. cit., Vol. I, "Carriage," Plate 2, 1845; Miller, op. cit., p. 339.

175 RMC, Mould, op. cit., p. 324.

176 Spearman (1828), op. cit., pp. 48, 114 and (1844), op. cit. "Car," unpaginated; Griffiths (1839), op. cit., p. 62 and (1840), op. cit., p. 69 and (1852), op. cit., p. 67; Miller, op. cit., pp. 334-8, 375.

177 RMC, Mould, op. cit., p. 324.

178 Griffiths (1839), op. cit., p. 62.

179 Spearman (1828), op. cit., p. 115.

180 Griffiths (1839), op. cit., p. 62 and (1840), op. cit., p. 69 and (1852), op. cit., p. 67; Miller, op. cit., pp. 334-8, 375.

181 *Aide-Mémoire* (1846), op. cit., Vol. I, "Carriage," Plate 2, 1845.

182 Hogg, op. cit., pp. 101-2; Hughes, *Smooth-Bore*, op. cit., p. 104.

183 Rudyerd, op. cit., Plate 30, illustrates the bolster hoop as a flat strap.

184 Muller (1780), op. cit., p. 117; cf. Adye (1766), op. cit., p. 54.

185 RAI, Borgard, Practtis of Artillery, *circa* 1714, plate untitled of a carriage and limber and "An Explanation of a 3-Pounder...C is the Limber &c;" RAI, Adye (1766), op. cit., pp. 53-6, Plate 7; Muller (1780), op. cit., pp. 116-18, Plate XIII; Smith, op. cit., pp. 53-4, Plate VII; Rudyerd, op. cit., Plates 24, 25, 29-31, 34-6; Landmann, *Principles*, op. cit., Plates 4, 5.

186 RAI, Adye (op. cit.), pp. 56-7. The absence of references to a light 3-pounder limber may indicate that the light 3-pounder was mounted on a galloper carriage.

187 RAI, "A particular account of the Alterations made in the Light 6 Por. Carriges in the Year 1776, by the order of the Right Honourable Lord Visct. Townshend Master General of the Ordnance, &ca. — also the reasons for making them;" Caruana, *The Light 6-Pdr...*, op. cit., pp. 11-21; Rudyerd, op. cit., Plate 40.

188 Caruana, Grasshoppers and Butterflies..., op. cit., pp. 8-9, show the carriages with pintle holes and plates for limbers.

189 RAI, Defence of the Coast, "An Account of the Field Pieces which His Grace the Duke of Richmond ordered to be constructed in 1788" by William Congreve, pp. 180-1; Caruana, "The Introduction of the Block Trail...," op. cit., pp. 3-7 passim.

190 RMC, Mould, op. cit., p. 156; RAI, RCD, Photo-lithograph, Plate No. 25, 1867.

191 See RCD, Plate No. 25, detail, for manner of securing the key in the end of the pintle.

192 Aide-Mémoire (1846), op. cit., Vol. I, "Carriage," Plates 23, 24, 1845 showed two platform boards; but (1853), op. cit., Vol. I, "Carriage," Plates 12, 13, 1852, showed only one.

193 RAI, Richardson, op. cit., unpaginated; PRO, Supply Department Records, Supp. 5, 76, "Notes on Manufactures...," pp. 10-11; Owen, Elementary, pp. 58-9. This description is based on circa 1860 sources, but most of the details were evident in the Aide-Mémoire drawings.

194 Quarterly List of Changes, 547, approved 21 June 1862.

195 Ibid., 101, approved 23 April 1860.

196 Ibid., 619, approved 30 Aug. 1862.

197 RMC, Mould, op. cit., p. 169.

198 RAI, Shuttleworth Drawings, "Medium 12 Pounder," circa 1820.

199 PRO, Supply Department Records, Supp. 5, 76, "Notes on the Manufactures...," op. cit., p. 33; Aide-Mémoire (1846), op. cit., Vol. I, Plates 12, 13, 1845.

200 Aide-Mémoire (1853), op. cit., Vol. I, p. 215.

201 RAI, RCD, Photo-lithograph, Plate 6, 1866.

202 The 1866 RCD lithograph does not show the yoke hoop and couplng plate, but a later version of the same plate, undated but made between 1871 and 1876, shows these pieces of iron work. Original at R.C.M.I., Toronto; copy at Environment Canada – Parks, Ottawa.

203 Straith, Plans... (1841), op. cit., "Artillery" Plate 2.

204 Aide-Mémoire (1846), op. cit., Vol. I, Plate 10, 1845.

205 Straith A Treatise on Fortifications (1858), op. cit., "Artillery," Plates I, III.

206 RAI, RCD, Photo-lithographs, Plates 44, 45, 1869.

207 RAI, RCD, Photo-lithographs, Plates 48, 49; Miller, op. cit., p. 240.

Gun Sleighs

1 RAI, Adye, (1766), op.cit. p. 69.

2 Ibid., Plate 12, "Slade for a 5 1/2 Inch Howitz." For a 6-pounder the sleigh was made proportionally longer.

3 John Knox, An Historical Journal of the Campaigns in North America for the Years 1757, 1758, 1759, and 1760, ed. Arthur G. Doughty (Toronto: The Chaplain Society, 1914), Vol. 2, pp. 326, 335 and fn.

4 John D. Chown, "The Gun Sleigh Additional Notes, " The Canadian Journal of Arms Collecting," Vol. 9, No. 4 (Nov. 1971), pp 135-6; Adrian B. Caruana, "Artillery Sledges & Gun Sleighs in North America, 1778-1783," The Canadian Journal: Arms Collecting, Vol. 16, No. 1 (Feb. 1978), pp. 8-9.

5 Caruana, "Artillery Sledges," pp.8-13.

6 Captain Townsend, "Remarks on Sleigh Carriages in the service of Artillery," Minutes of Proceedings of the Royal Artillery Institution, Vol. I (1858), p.115.

7 R.W. Adye, Notebook, circa 1800, "Elevation, Plan and Section of a Slay and Carriage for a Light 6 Pounder." In possession of Fort Malden National Historic Park, Amherstburg, Ontario.

8 RAI, Collected Military Papers, Vol. 2, "Gun Sleighs used in Canada with

proposals for altering them," unsigned draft attributed to Lt.-Col. Sir William Robe, who was in Canada 1800-06.

9 Townsend, op.cit., p. 115.

10 Ibid., p. 115.

11 RAI, John Cockburn, Notes on Artillery, MS notebook, circa 1820; Caruana, "Artillery Sledges," p. 10.

12 Townsend, op.cit., p. 116. Cf. Griffiths (1862), op.cit., p. 161-2; Miller, op.cit., p. 131.

13 RAI, Cockburn, op. cit.

14 Great Britain. War Office, Manual of Field Artillery Exercises (London: H.M.S.O., 1861), Plate LXVII, opposite p. 181. Drawings of gun and ammunition sleighs. See also, J.D. Chown, "The Gun Sleigh," The Canadian Journal of Arms Collecting, Vol. 4, No. 4 (Nov. 1966), p. 151.

15 Townsend, op. cit., fn. p. 116.

Traversing Platforms

1 John Rutherford: 2nd Lieut., 12/7/81; Lieut., 21/5/90; Capt.-Lt., 1/12/95; Capt., 11/9/98; served in Holland, 1793-5; Grenada, 1796; Holland, 1799; to Staff Crops, 1/5/1800; died on passage home from Gibraltar, 1813. R. F. Edwards, ed., Roll of Officers of the Corps of Royal Engineers, from 1660 to 1898 (Chatham: Royal Engineers Institute, 1898), p. 11.

2 RAI, Collected Military Papers, op. cit., Vol. 2, pp. 243-4.

3 Ibid., p. 44.

4 Charles P. de Volpi, Nova Scotia; A Pictorial Record (Longman Canada Limited, 1974), Plate 41, "View of Halifax from George's Island," Drawn, engraved and published by G. J. Parkyns, London, April 29, 1801; NA, RG8, I, Vol. 982, "View of Halifax from Georges Island," G. I. Parkyns, aquatint, circa 1801.

5 Public Archives of Nova Scotia, MG 12, Great Britain, Army. Miscellaneous — General, Vol. 4, p. 12, Smyth to Horton, 15 August 1795; p. 40, Smyth to Horton, 1 July 1796.

6 Fort Malden N.H.P., R.W. Adye, Notebook, "Plan and Elevation of a 12 Pounder & Carriage Mounted upon a Traversing Platform," circa 1800.

7 NA, C-5549, A. Gray, " Detailed drawing of gun and emplacement , No. 363 U./P No 225/ D G," wash drawing. The NA notes that "An A. Gray was Quartermaster General from about 1809-1814" but beyond this nothing is known about the age and provenance of the drawing. The gun is clearly a pre-Blomefield model, so that a date of about 1800 or even 1812 is not unreasonable.

8 RAI, Copy of a letter to John, Earl of Chatham, M.G.O., on differences of opinion regarding traversing platforms from Lieut-General Robert Morse Inspector-general of Fortifications, 19 July 1804.

9 NA, RG 8, I, Vol. 384, p. 206, Crew to R.O., Quebec, 15 April 1807.

10 Adye (1813), op. cit., pp. 287-8 and (1827), p. 270.

11 NA, Prince of Wales Tower, view, section and floor plans 1812..., cited in Ivan J. Saunders, "A History of Martello Towers in the Defence of British North America, 1796-1871," Canadian Historic Sites: Occasional Papers in Archaeology and History, No. 15 (1976), p. 93; NA, John Elliott Woolford, "The Côteau Rapids from the Fort, 1821;" P. J. Bainbrigge, "Quebec from the Citadel," in Mary Allodi, Canadian Watercolours and Drawings in the Royal Ontario Museum (Toronto: Royal Ontario Museum, 1974), Vol. I, Plate 58; NA, J. S. Clow, "Halifax from the Eastern Battery"; NA, H3/45 — Kingston, 1851, "Kingston, Fort Henry, Eastern Angle over the Magazine."

12 NA, RG8, I, Vol. 1418, pp. 127, 130, October, 1848.

13 RAI, Shuttleworth Drawings, "Elevation of a Traversing Platform with Pivot in the Centre," two drawings, 19 June and 6 July 1819; Aide-Mémoire, op. cit. (1846), Vol. I, Coast Defences, Plate 6.

14 NA, J. S. Clow, "Halifax from the Eastern Battery" clearly shows the rear footboard, not evident elsewhere. The estimates of repairs, NA, RG8, I, Vol. 1418, pp. 127, 130, October 1848 gave dimensions for side and rear foot boards.

15 Aide-Mémoire (1853), op. cit., Vol. I, p. 291.

16 RAI, Shuttleworth Drawings, "Elevation of a Traversing Platform with Pivot in the Centre," two drawings, 19 June and 6 July 1819; RAI, Robert Cockburn, "Practical Course of Instruction;" NA, J.S. Clow, "Halifax from the Eastern Battery."

17 Aide-Mémoire (1853), op. cit., Vol. I, p. 291.

18 RAI, Reports on Artillery, "Abstract of Recommendations and Observations taken from a Report of a Committee of Officers of the Royal Artillery and Royal Engineers... approved by the Master General and Board 28th January 1853 M/612," p. 2.

19 Owen, Elementary, op. cit, p. 73; RAI, Reports on Artillery, Tulloh to Lefroy, Woolwich, 9 April 1859.

20 Miller, op. cit., p. 273.

21 Straith, A Treatise on Fortifications, (1846), op. cit., pp. 263-4; Aide-Mémoire (1853), op. cit., Vol. I, pp. 209, 290. Anthony Emmett was commissioned as 2nd-Lt. in the Royal Engineers in 1808 and served in the Peninsula and at New Orleans. He achieved the rank of Lt.-Col. in 1837, Col. in 1851, and retired as a Maj-Gen. in 1855. He died at Brighton in 1872. See Edwards, Roll of Officers of the Corps of Royal Engineers from 1660 to 1898, op. cit., p. 17.

22 Aide-Mémoire (1846), op. cit., Vol. I, Defence of Coasts, Plate I; Owen, Elementary, op. cit., p. 73, Plate 15.

23 Aide-Mémoire (1846), op. cit., Vol. I, Defence of Coasts, Plate I; Miller, op.cit, pp. 273-5; Owen, Elementary, op. cit., pp. 73-4.

24 Aide-Mémoire (1846), op. cit., Vol. I, Defence of Coasts, Plate I.

25 Straith, Plates (1852), op. cit., Plate XVIII. I have not located the Plates for the 1846 edition, but in all likelihood it was the same.

26 Aide-Mémoire (1846), op. cit., Vol. I, Defence of Coasts, Plate I; NA, PAC, MG13, WO55/884, p. 317, "Plan and section showing racers for a 56 Pr to be placed in salient angle of the advanced battery," Fort Henry, 24 July 1849.

27 RAI, Strange, Drawings on Artillery, MS notebook, circa 1851, "56 Pr. 11 ft. 98 cwt on a Dwarf Traversing Platform."

28 Griffiths (1852), op. cit., p. 67 and (1859), p. 68.

29 Griffiths (1862), op. cit., p. 68.

30 RAI, RDC, Lithographs, Plate 60, "Drawing of New Platform either casemate or dwarf suitable to any radius" approved 29 May 1860; Plate 60 B, "N.P. Traversing Platform fitted as a dwarf...," approved 9 Aug. 1864, both photo-lithographed 1868.

31 Miller, op. cit., p. 273; Owen, Elementary, op. cit., p. 74; RAI, RCD, Lithographs, Plate 60.

32 RAI, RCD, Lithographs, Plates 60, 60A, 60B; RAI, Reports on Artillery, "Confidential Circular 1 Jan. 1861 promulgating report of Committee on Coast Batteries dated July 1860," pp. 3-4.

33 Aide-Mémoire (1853), op. cit., Vol. I, p. 210; RAI, RCD Lithographs, Plate 60; Owen, Elementary, op. cit., p. 74.

34 RAI, Reports on Artillery, "Confidential Circular 1 Jan. 1861 promulgating report of Committee on Coast Batteries, dated July 1860," p. 4 and Note.

35 RAI, Reports on Artillery, "Abstract and Observations ... for Coast Batteries...

1853," p. 2; Miller, op. cit., p. 274; Owen, Elementary op. cit., p. 74.

36 Miller, op. cit., fn, p. 274.

37 Hughes, Smooth-Bore, op. cit., p. 117. A drawing by Campion, circa 1845, shows the platform mounted on a front pivot; Owen, Elementary, op. cit., p. 74.

38 Miller, op. cit., p. 274.

39 Aide-Mémoire (1853), op. cit., Vol. I, pp. 217-290.

40 Ibid, Vol. I, p. 290-1.

41 RAI, Reports on Artillery, "Abstract and Observations... ... for Coast Batteries... 1853," p. 2.

42 Ibid., "Confidential Circular 1 Jan. 1861 promulgating report of Committee on Coast Batteries dated July 1860," p. 4.

43 Aide-Mémoire (1846), op. cit. Vol. I, Coast Defences, Plates 2-3.

44 See Charles P. de Volpi, Québec (Longman Canada Limited, 1971), Plate 187, for a view of the Grand Battery in 1875.

45 Griffiths (1852), op. cit., p. 67 and (1859), p. 68.

Gins

1 The spelling Gin was used throughout the 18th century, but early in the next century Gyn began to appear and seems to have been preferred thereafter. Modern usage is Gin and this spelling will be used except in quotations.

2 The term cheek seems to have applied originally to two triangular pieces of wood, strapped and bolted to the two poles, into which the ends of the windlass were fitted, but eventually the term came to mean the poles to which the cheeks were attached.

3 Initially the tackle was composed of two double blocks roved together, but by the 1820s a double and a treble block were used, and by the 1860s for very heavy guns two treble blocks.

4 RAI, Albert Borgard, "Practtis of Artillery," circa 1714.

5 Muller (1780), op. cit., pp. 143-4 and Plate XXVII. Cf. Adye (1766), op. cit., pp. 96-7, and Plate 20. Adye's description seems to derive from Muller's. By "windless" both authors must mean "block," two of which when roved together form the tackle.

6 Adye (1801), op. cit., p. 125 and (1813), op. cit., p. 191.

7 NA, RG 8, I, Vol. 384, p. 207, Crew to R. O., Quebec, 15 April 1807.

8 Adye (1813), op. cit., p. 191.

9 Ibid., p. 137 "The guns sic, gins of the new construction, have a small racket-wheel, and dropping paul sic , on the roller... "

10 Spearman (1828), op. cit., pp. 254, 389. Adye (1827), op. cit., p. 178 repeated his entry of 1813. Probably he was out of date.

11 RAI, John Cockburn, "Notes on Artillery," circa 1820; RAI, Robert Cockburn, "Practical Course of Instruction," 1830; RMC, Mould, op. cit., p. 221.

12 Aide-Mémoire (1853), op. cit., Vol. I, Derrick (Sheers & Gyn), Plate 3.

13 Griffiths (1847), op. cit., pp. 220, 222.

14 Griffiths (1862), op. cit., pp. 127-8; Miller, op. cit., pp. 355-6.

15 Miller, op. cit., pp. 355-6.

16 Lefroy (1867), op. cit., p. 180.

17 RAI, RCD, Photo-lithograph, Plate 72A, "18 Ft. Triangle Gyn. Strengthened for Service with Heavy Ordnance," approved 6 March 1866.

18 RAI, John Cockburn, "Notes on Artillery," circa 1820.

19 Cf. Ibid., and RAI, Robert Cockburn, "Practical Course of Instruction," Woolwich, 1830.

20 Griffiths (1862), op. cit., p. 129.

21 Griffiths (1847), op. cit., p. 220 and (1862), op. cit., p. 129; Miller, op. cit.,

pp. 355-6. Miller indicated that the lashings were 7 fathoms (42 feet) long, but it is not clear if he means each separately or together.

22 RAI, RCD, Photo-lithograph, Plate 73, "Gibraltar Gin," approved 2 November 1866.

23 RMC, Mould, op. cit., p. 222.

24 Griffiths (1847), op. cit., p. 224. See also Miller, op. cit., p. 356, for a short description.

25 RAI, RCD, Photo-lithograph, Plate 73, "Bell's Gyn," approved 2 November 1866.

Gunpowder and Cartridges

1 Partington, op. cit., p. 324.

2 Ibid., pp. 323-9; Vivian Dering Majendie, *Ammunition: A Descriptive Treatise on the Different Projectiles, Charges, Fuzes, Rockets, etc. at Present in Use for Land and Sea Service...Part I. Ammunition for Smooth-bore Ordnance*, London, Eyre - Spottiswode for HMSO, 1867, [hereafter cited as *Ammunition*], pp. 131-6; Goodenough, op. cit., pp. 1-3.

3 W.H. Simmons, "A Short History of the Royal Gunpowder Factory at Waltham Abbey," n.p., n.d., typescript, p. 17; Hall, op. cit., p. 60; Hughes, *Smooth-Bore*, op. cit., p. 43.

4 William Congreve, *A Statement of Facts relative to the Savings Which have Arisen from Manufacturing Gunpowder at the Royal Powder Mills; and of the Improvements which have been made in its strength & durability since the year 1783* (London: James Whiting, 1811), p. 11.

5 Simmons, op. cit., Appendix III, p. 89.

6 Smith, op. cit., p. 127; RAI, Frazer, Work Notes, op. cit., pp. 42-4, "Method of Refining Salt Petre in 1784 & 1785," and pp. 64-6, "Method of Melting & casting salt petre into cakes — 1787"; RAI, untitled MS, *circa* 1800, op. cit., pp. 2-3, "Method of refining Salt Petre, and p. 4," "Method of casting Salt Petre into Cakes," DND, Fitzhugh, op. cit., pp. 195-6; *Aide-Mémoire* (1850), op. cit., Vol. 2, pp. 229-30.

7 *Aide-Mémoire* (1850), op. cit., Vol. 2, pp. 230-1; Straith (1858), op. cit., p. 65; Goodenough, op. cit., pp. 5-7.

8 RAI, Adye (1766), op. cit., p. 110.

9 RAI, Frazer, Laboratory Work, op. cit., pp. 52-8, "Method of Extracting Salt petre with the New press: Invented by Colonel Congreve"; RAI, Frazer, Work Notes, op. cit., pp. 34-40, "Method of Extracting Salt Petre from Damaged Powder with the new Press Invented by Major Congreve"; RAI, untitled MS, *circa* 1800, pp. 1-2, "Method of extracting Salt Petre from damaged Gun Powder with a press; invented by Major Congreve for that purpose."

10 RAI, Congreve, *A Statement*..., op. cit., pp. 20-1.

11 RAI, Frazer, Laboratory Work, op. cit., p. 82.

12 Ibid., pp. 79-80; DND, Fitzhugh, op. cit., p. 197; Straith, *A Treatise on Fortifications* (1846), op. cit., p. 523.

13 Spearman (1844), op. cit., "Gunpowder."

14 *Aide-Mémoire* (1850), op. cit., Vol. 2, pp. 233-4; Straith (1858), op. cit., pp. 66-7; RMC, Lloyd, op. cit., pp. 231-4; Goodenough, op cit., pp. 7-8.

15 Rees, *Cyclopaedia*, op. cit., Vol. 7, "Charcoal."

16 Simmons, op. cit., pp. 23-4. The idea seems not to have been original with Watson, but had been suggested some time before by Dr. George Fordyce, a physician and eminent chemist. According to Congreve, the elder, "The form of this retort was first recommended by Dr. George Fordyce, and afterwards improved by Gen. Congreve...," RAI, Congreve, *A Statement of Facts*..., op. cit., pp. 26-7.

17 RAI, Frazer, Laboratory Work, op. cit., pp. 86-90, "Process for Charring wood in Iron cylinders for making Gunpowder at Faversham"; Simmons, op. cit., pp. 93-4, Appendix IV, "The Manufacture of Cylinder Charcoal in Sussex" from Young's "Agriculture of Sussex" (1808).

18 Richard Coleman, a clerk at the Royal Gunpowder Factory at Waltham Abbey in the 1790s, was very knowlegeable about gunpowder making. If he invented the slip, either he lived to quite an old age or its introduction occurred quite early. The first mention of the slip that has been found was in 1846. See Straith, A Treatise on Fortifications (1846), op. cit., p. 524.

19 Straith (1846), op. cit., pp. 524-5 and (1858), op. cit., pp. 67-70; Aide-Mémoire (1850), op. cit., Vol. 2, pp. 232-3; Goodenough, op. cit., pp. 8-10.

20 RAI, Glegg, op. cit., p. 110; Smith, op. cit., p. 127; RAI, Frazer, Work Notes, op. cit., pp. 45-6, "Method of Pulverizing Salt Petre 1800"; RMC, Mould, op. cit., p. 49; RAI, Swanston, Papers, "A Course of Laboratory Instructions for the Royal Regiment of Artillery 1826," bound MS, pp. 41-2.

21 RAI, Frazer, Laborary Work, op. cit., pp. 72-4; Majendie, op. cit., pp. 314-5.

22 RAI, Frazer, Laboratory Work, op. cit., p. 74.

23 Aide-Mémoire (1850), Vol. 2, op. cit., p. 234; Straith (1858), op. cit., p. 67; Goodenough, op. cit., p. 10.

24 Aide-Mémoire (1850), Vol. 2, op. cit., p. 234; Straith (1858), op. cit., p. 67; Goodenough, op. cit., p. 11.

25 RAI, "Repository Course...Gunpowder...," para. 8; Spearman (1844), op. cit., "Gunpowder."

26 DND, Fitzhugh, op. cit., pp. 200-1; Aide-Mémoire (1850), op. cit., Vol. 2, pp. 234-5; Straith A Treatise on Fortifications (1858), op. cit., p. 71; Goodenough, op. cit., p. 11.

27 William Congreve, A Short Account of the Improvements in Gun-Powder made by Sir William Congreve, Comptroller of the Royal Laboratory: being the Substance of the Specification of a Patent Granted to Him the 3d of July, 1815 (London: J. Whiting, 1818), pp. 3-6.

28 Smith, op. cit., pp. 175-6.

29 RAI, Adye (1766), op. cit., p. 104; Simmons, op. cit., Appendix III, p. 90.

30 Rees, Cyclopaedia, op, cit., Vol. 17, "Gunpowder," 12 G.III, c.61.

31 Simmons, op. cit., p. 17, Appendix III, p. 90; Spearman (1844), op. cit., "Gunpowder"; Aide-Mémoire (1850), op. cit., Vol. 2, pp. 235-6; Straith, A Treatise on Fortifications (1858), op. cit., pp. 71-2; Goodenough, op. cit., pp. 11-12.

32 RAI, Glegg, op. cit., p. 86; RAI, Adye (1766), op. cit., pp. 104-5; Smith, op. cit., pp. 126-7.

33 Congreve, A Statement of Facts..., op. cit., p. 24; Simmons, op. cit., Appendix III, p. 90.

34 RAI, "Repository Course...Gunpowder..., para. 11.

35 DCB, Vol. 6, "Joseph Bramah," pp. 202-3; Simmons, op. cit., p. 67; Spearman (1844), op. cit., "Gunpowder."

36 Aide-Mémoire (1850), op. cit., Vol. 2, pp. 237-8; Straith, A Treatise on Fortifications (1858), op. cit., pp. 73-4; Goodenough, op. cit., pp. 13-14.

37 RAI, Adye (1766), op. cit., pp. 104-5.

38 Simmons, op. cit., Appendix III, p. 90; Spearman (1844), op. cit., "Gunpowder."

39 RAI, Congreve, A Short Account..., op. cit., pp. 8-14.

40 RAI, "Repository Course...Gunpowder...," para. 18.

41 Aide-Mémoire (1850), op. cit., Vol. 2, pp. 238-9; Straith (1858), op. cit., pp. 74-6; Goodenough, op. cit., pp. 14-15.

42 Congreve, A Statement of Facts..., op. cit., p. 24; Simmons, op. cit., Appendix III, p. 90; RAI, "Repository Course...Gunpowder...," op. cit., para. 13-14; Spear-

man (1844), op. cit., "Gunpowder."

43 Aide-Mémoire (1850), op. cit., Vol. 2, pp. 239-40; Straith (1858), op. cit. p. 77; RMC, Lloyd, op. cit., pp. 244-5; Goodenough, op. cit., pp. 16-17.

44 Simmons, op. cit., Appendix III, p. 90.

45 Ibid., p. 31; RAI, "Repository Course...Gunpowder...," para. 15 and 17; Spearman (1844), op. cit., "Gunpowder." Aide-Mémoire (1858), op. cit., Vol. 2, p. 240; Straith (1858), op. cit., p. 77, Goodenough, op. cit., p. 17.

46 For detailed list of charges see RAI, James, op. cit., p. 27; RAI, Glegg, op. cit., p. 2; Smith, op. cit., pp. 46, 62, 303; RCMI, Paul, Notebooks, op. cit., Vol. 3, p. 40; Adye (1813), op. cit., pp. 98-9; RAI, Denning, notebook, op. cit., p. 49; RAI, Boxer, Diagrams of Guns, passim.; Lefroy (1867), op cit., pp. 129-30.

47 Congreve, A Statement of Facts..., op. cit., p. 11.

48 Adye (1801), op. cit., p. iv.

49 NA, RG 8, I, Vol. 416, p. 16, "Return of Damaged and ? Gun Powder in the Ordnance Magazines in the Canadas," Quebec, 31 May 1823; p. 62, R.O. to Col. Darling, Quebec, 19 June 1823.

50 Simmons, op. cit., pp. 11, 15; Congreve, A Statement of Facts..., op. cit., pp. 27-29.

51 RAI, Adye (1766), op. cit., p. 111; Majendie, Ammunition, op. cit., p. 128.

52 Majendie, Ammunition, op. cit., p. 128.

53 RAI, Adye (1766), op. cit., p. 111; Muller (1780), op. cit., p. 201; Smith, op. cit., pp. 137-8.

54 Padfield, op. cit., p. 102, citing Admiralty Order, 21 Oct. 1755, cited by Dudley Pope, At Twelve Mr. Byng was Shot (London; Weidenfeld and Nicolson 1962).

55 Majendie, op. cit., p. 129.

56 NA, RG 8, I, Vol. 1707, p. 196, "Return of ordnance ammunition and Stores remaining under my charge at this Post," Kingston, 20 Feb. 1813; Vol. 395, "Laden on board the Thetes...," undated copy, Spring 1816, pp. 55-6; "Laden on board the Regalia...," undated copy, Spring 1816, pp. 59, 62.

57 RAI, Swanston, Papers, "A Course of Laboratory Instructions for the Royal Regiment of Artillery 1826," pp. 112-3.

58 NA, RG 8, I, Vol. 381, p. 92, "Return of Ordnance & Ordnance Stores..., New Brunswick, 13 June 1793; pp. 162-3, "Proceedings of a board of survey...," 18-24 Sept. 1793; Vol. 1706, p. 24, "Return of Ordnance, Ammunition and Stores Stationed at the different BAtteries..., Halifax, 1 May 1811; p. 27, Return of Ordnance and Ammunition Stationed at Fort Clarence..., Halifax, 1 May 1811; Vol. 1707, pp. 88-90, "Return of Ordnance and Ordnance Stores in the Garrison at Quebec...," Quebec, 17 Dec. 1812; p. 196, "Return of ordnance ammunition and Stores..., Kingston, 20 Feb. 1813; Vol. 388, p. 109, "Laden on board the Ogle Barong[?] Transport...," Chatham Navy Yard, 2 March 1814.

59 RAI, "Laboratory Notes, circa, 1798" p. 11, "Report of the Dimensions of Cartridge and other Paper to be used in the R^{l} Laboratory as settled the 19th Dec^{r} 1795." A note appended read in part "...for Cured Paper Cart^{s} with and without flannel Bottoms...."

60 RAI, James, op. cit., p. 62.

61 RAI, Report of a Committee..., op. cit., (1819), pp. 128-9.

62 RAI, Swanston, Papers, "A Course of Laboratory Instructions for the Royal Regiment of Artillery 1826", pp. 112-3, "The above are the only discriptions sic of paper Cartridges in the service and they are now nearly obsolete."

63 RCMI, Paul, Notebooks, op. cit., Vol. 3, p. 127.

64 RAI, William Caffin, Laboratory Notes, 1797, "Method pursued in Curing Paper for Cannon Cartridges in the Royal Laboratory," 17 Feb. 1797.

65 RAI, Frazer, Laboratory Work, op. cit., p. 27; RMC, Mould, op. cit., p. 47.

66 Muller (1780), op. cit., p. 201.
67 RAI, William Caffin, Laboratory Notes, 1797, "Method pursued in Curing Paper for Cannon Cartridges in the Royal Laboratory," 17 Feb. 1797.
68 RCMI, Paul, Notebooks, op. cit., Vol. 3, p. 27.
69 RMC, Noble, op. cit., p. 348; RAI, Denning, Notebook, op. cit., p. 51.
70 RMC, Mould, op. cit., p. 47; RMC, Noble, op. cit., p. 348; RAI, Denning, Notebook, op. cit., p. 51; Majendie, Ammunition, op. cit., pp. 150-5.
71 "Flannel" was commonly used but as early as the 1820s "serge" began to appear. It is not clear if this indicates a change in material or not; flannel and serge were both woollens, and at times the terms seemed to be interchangeable.
72 While the cartridge for the 12-pounder howitzer was made from a single piece of serge, its sides were slightly sloped so that when it was sewn together it had the required conical form.
73 Because the 5 lb. cartridge for the 8-inch gun would be shorter than the chamber, a coal-dust wad (a blue serge bag filled with coal dust) was choked into the cartridge over the powder to give it the required length. For L.S. saluting the wad was not used. Cork and sawdust had also been tried but coal-dust was found the most suitable. Majendie, Ammunition, op. cit., p. 155.
74 Two different sizes of worsted thread were used: for sewing the seams, "No. 20 Hank," or about 75 needles full to the ounce; for closing the cartridge and making the hoops, a shorter worsted, "No. 14 Hank," or from 38 to 40 needles full to the ounce. Majendie, op. cit., p. 151, fn. 5; p. 152, fn. 6.
75 RMC, Noble, op.cit., pp. 349-50; RAI, Denning, Notebook, op. cit., p. 51; Majendie, Ammunition, op. cit., p. 130, fn. 7.
76 Majendie, Ammunition, op. cit., p. 152, War Office Circular 822, para. 728, 24 March 1863.
77 Majendie, Ammunition, op. cit., p. 154, War Office Circular 835, para. 763, 28 May 1863.

Projectiles

1 Majendie, Ammunition, op. cit., p. 5.
2 O.F.G. Hogg, English Artillery 1326-1716 (London :Royal Artillery Institution, (1963), p. 49; Hughes, Smooth-Bore, op. cit., p. 51; Majendie, Ammunition, op. cit., p. 5.
3 Muller (1780), op. cit., p. 4.
4 RAI, Glegg, op. cit., p. 75.
5 Muller (1780), op. cit., pp. 5-6.
6 RAI, "Mem. of Col. Millars 68 P^{r}. Gun ...," p. 9. "The low Guage [sic] is the True diameter of the Shot."
7 RAI, Glegg, op. cit., pp. 75-7, 112, 134; Muller (1780), op. cit., p. 6; RAI, Landmann, "Notes on Artillery," op. cit., pp. 11-12; RAI, Bogue, circa 1795, op. cit., pp. 139-40; Adye (1801), op. cit., p. 195 and (1813), p. 343; RAI, "Mem. of Col. Millars 68 P^{r}. Gun ...," p. 9.
8 Benjamin Robins, New Principles of Gunnery (London: J. Nourse, 1742), p. ; Muller (1780), op. cit., pp. 64-5.
9 DNB, pp. 351-3.
10 RAI, Reports on Artillery, 1854, "Papers submitted to the Committee on Ordnance, November 23, 1857..., No. 13, Douglas to Chapman, 10 June 1817, and enclosure; No. 14, Farrington to Mulgrave, 12 June 1818; No. 15, Farrington to Mulgrave, 8 July 1818.
11 Ibid., No. 16, Farrington to Wellington, 3 May 1819; No. 19, "Report of Committee on Sir Howard Douglas's Proposition for reducing the Windage in Ordnance used for Sea Service, 30 April 1819."

12 Adye (1827), op. cit., p. 192.

13 The high and low gauges are from ibid., p. 192.

14 RAI, Report on Artillery, 1854, "Papers submitted to the Committee on Ordnance, November 23, 1857..., No. 17, Dundas to Byham, 24 Feb. 1843; No. 18, Downman to Murray, 23 March 1843, and enclosure, "Return of Brass Field Ordnance and Shot. - Woolwich, March 23, 1843."

15 Ibid., "Table showing the Calibres of Guns Mortars & Howitzers and the Diameters of Shot and Shell as now in the Service..., 27 Jan. 1857; Lefroy (1867), op. cit., pp. 142-3.

16 J.A. Dahlgren, *Shells and Shell-Guns* (Philadelphia: King & Baird, London: Trübner & Co., 1857), pp. 1-7; Majendie, *Ammunition*, op. cit., pp. 21-3.

17 RAI, Glegg, op. cit., p. 4; RAI, Walton, op. cit., unpaginated.

18 RAI, Glegg, op. cit., pp. 71, 73; RAI, "Practice Book 1760," unpaginated; RAI, Adye (1766), op. cit., p. 37.

19 The sums of the interior diameter and the thickness, top and bottom, of both the 5-1/2-inch and 4-2/5-inch shells do not equal their exterior diameters.

20 RAI, Glegg, op. cit., p. 69.

21 RAI, Adye (1766), op. cit., p. 36. See also Muller (1780), op. cit., p. 90.

22 Muller (1780), op. cit., p. 90.

23 RAI, Defense of the Coast, op. cit., p. 112.

24 Adye (1801), op. cit., p. 192.

25 Joseph Jobé, *Guns: An Illustrated History of Artillery* (Greenwich, Conn.: New York Graphic Society, 1971), p. 130.

26 Robertson, *The Evolution of Naval Armament*, op. cit., p. 163, fn 1, citing *Proceedings of the Royal Artillery Institution*, Vol. 4.

27 RAI, Laboratory Notes, *circa* 1798, op. cit., p. 44.

28 Ibid., p. 44.

29 Adye (1801), op. cit., p. 191 and (1813), p. 336.

30 RAI, Defence of the Coast, op. cit., p. 114.

31 RAI, Laboratory Notes, *circa* 1798, op. cit., p. 44.

32 Adye (1801), op. cit., p. 190 and (1813), p. 335.

33 RAI, Laboratory Notes, *circa* 1798, op. cit., p. 44. A table given earlier in this notebook, p. 38, gave the high gauge of the 13-, 10-, 8-, and 5-1/2-inch shells as 12.85, 9.85, 7.85, and 5.25 respectively (the last an obvious transpositional error for 5.52). The low gauge and both gauges of the 4-2/5-inch shell were the same as in the later table.

34 Adye (1801), op. cit., p. 190 and (1813), op. cit., p. 335.

35 Adye (1827), op. cit., p. 192; Spearman (1828), op. cit., pp. 370-1 and (1844), unpaginated.

36 Straith, *A Treatise on Fortifications* (1846), op. cit., p. 734; *Aide-Mémoire*, (1853), op. cit., Vol. I, p. 62; RAI, Reports on Artillery, 1854, "Table showing ... the Diameters of Shot and Shell as now in the Service ...," 27 Jan. 1857; Majendie, *Ammunition*, op. cit., p. 325; Miller, op. cit., p. 393; Lefroy (1867), op. cit., pp. 77, 142-3.

37 RAI, Reports on Artillery, 1854, "Table showing ... the Diameters of Shot and Shell as now in the Service...," 27 Jan. 1857.

38 Majendie, *Ammunition*, op. cit., p. 325; Lefroy (1867), op. cit., pp. 77, 142.

39 Straith, *A Treatise on Fortifications* (1846). op. cit., p. 734.

40 Griffiths (1862), op. cit., p. 62.

41 Majendie, *Ammunition*, op. cit., p. 325; Lefroy (1867), op. cit., pp. 77, 142.

42 RAI, Reports on Artilery, 1854, "Table showing ... the diameters of Shot and Shell as now in the Service...," 27 Jan. 1857.

43 Majendie, *Ammunition*, op. cit., p. 325; Lefroy (1867), op. cit., p. 77, 142.

44 Griffiths (1840), op. cit., p. 91 (1847), p. 99 and (1852), p. 91; Spearman (1844), op. cit., unpaginated; RAI, Strange, op. cit.; RAI, Boxer, Diagrams of Guns, Plate XLII; RMC, Noble, op. cit. The usual outside diameter given for the shells from 10-in. to 32-pdr. is 1.2 in., but Spearman gives 1.22 inches.

45 Plugs were of white metal until 1858 when gun metal was approved for field service shells and until 1859 when it was approved for all common shells.

46 Majendie, Ammunition, op. cit., pp. 24-6.

47 Ibid., p. 325; Lefroy (1867). op. cit., p. 77.

48 RAI, Strange, op. cit.; RMC, Noble, op. cit.; RAI, Boxer, Diagrams of Guns, Plate XL; Spearman (1844), op. cit., Cf. Griffiths (1852), op. cit., p. 91, for slightly different diameters.

49 Majendie, Ammunition, op. cit., p. 325.

50 Ibid., pp. 38, 99.

51 Ibid., p. 37.

52 Muller (1780), op. cit., p. 89. Cf. Majendie, Ammunition, op. cit., p. 36, fn. 6, for a much earlier reference.

53 Majendie, Ammunition, op. cit., pp. 36-7, 124-5.

54 RAI, Strange, op. cit., "Naval 8 in Shell"; RMC, Noble, op. cit., "Naval 8 inch Shell"; RAI, Boxer, Diagrams of Guns, Plate XLI; Majendie, op. cit., p. 325; Lefroy (1867), op. cit., p. 77.

55 Straith Plans (1841), op. cit., p. 103; Griffiths (1843), op. cit., p. 86.

56 That the original shape of the naval shell's fuze hole was conical is speculation, premised on the knowledge that the land service shell's fuze hole was conical.

57 See diagrams in Strange, Noble, and Boxer, note 54, above.

58 Majendie, Ammunition, op. cit., pp. 30, 245.

59 Ibid., p. 325; Lefroy (1867), op. cit., p. 77.

60 Ibid., pp. 31-2, 112.

61 Ibid., p. 168.

62 Muller (1780), op. cit., p. 90.

63 RAI, Laboratory Notes, circa 1798, op. cit., p. 43; RAI, Fry, (circa 1800-4), op. cit., unpaginated.

64 Fortune, op. cit., p. 21; Smith, op. cit., p. 230; Mountaine, op. cit., p. 89. Mountaine indicated that the quantities were experimented with in 1742-3; he gave 9 lbs. 4 oz. as the amount for a 13-inch shell, perhaps a typographical error.

65 RAI, "Practice Book circa 1760," op. cit., unpaginated; RAI, "Artillery Practice & Stores," circa 1780, op. cit., pp. 7-8 (On p. 7 it was refered to as "Gen'l. Desaguliers's allowance); Adye (1801), op. cit., p. 190 and (1813), p. 335; Griffiths (1839), op. cit., p. 80 and (1847), p. 99. Griffiths gave the bursting charge of the 13-in. shell as 6-1/2-lbs. and of the 5-1/2-inch shell as 10 oz.

66 Adye (1813), op. cit., p. 336.

67 Straith, A Treatise on Fortifications (1846), op. cit., p. 675 and (1852), p. 230.

68 Majendie, Ammunition, op. cit., p. 169.

69 Ibid., pp. 168, 340 (Table XVI).

70 Owen, Lectures, 4th ed. p. 78 quoted by Ibid., p. 170, fn. 6.

71 Majendie, Ammunition, op. cit., pp. 170-2.

72 Ibid., pp. 172-3.

73 Majendie, Ammunition, op. cit., p. 67.

74 Ibid., p. 68.

75 Cited by Blackmore, op. cit., p. 222.

76 RAI, Albert Borgard, "Practtis of Artillery," "... 12 Inch Carcass in full proportion...".

77 Smith, op. cit., p. 286; RAI, Adye (1766), op. cit., p. 38; RAI, "Artillery

Experiments, 1770-1; 1773" op. cit., unpaginated; RAI, Meridith, "Laboratory Notes, 1780," op. cit., p. 16. The earliest sources gave no woolded weight for either the 5-1/2 or 4-2/5 in. carcasses; later sources for only the 5-1/2 in.

78 RAI, Walton, op. cit., unpaginated; RAI, Frazer, Work Notes, op. cit., p. 152.

79 RAI, Walton, op. cit., unpaginated; RAI, Frazer, Work Notes, op. cit., pp. 152, 155-6.

80 *OED*, citing Chambers *Cycl.*, 1751.

81 Smith, op. cit., pp. 50-1.

82 RAI, Adye (1766), op. cit., pp. 127-9, Plate 21, p. 147.

83 RAI, Glegg, op. cit., pp. 45-6; RAI, "Practice Book 1760," op. cit., unpaginated; RAI, Adye (1766), op. cit., pp. 127-9; RAI, Williamson, Collection, *circa* 1770, op. cit., p. 92; RAI, "Artillery Experiments, 1770-1; 1773," op. cit., unpaginated; Smith, op. cit., pp. 51, 137, 287; RAI, Walton, op. cit., unpaginated; RAI, Frazer, Work Notes, op. cit., p. 143.

84 Adye (1801), op. cit., [illegible] 51.

85 RAI, Frazer, "Work Notes," op. cit., pp. 143-50; RAI, Untitled Notebook, *circa* 1800, pp. 23-5.

86 Muller (1780), op. cit., p. 206.

87 RAI, Collected Military Papers, op. cit., Vol. 2, Reed to ?, 24 March 1785.

88 Muller (1780), op. cit., p. 206; Smith, op. cit., p. 137.

89 Adye (1801), op. cit., p. 52 and (1813), op. cit., p. 87.

90 NA, RG 8, I, Vol. 384, p. 156a, "Return of Ordnance and Ordnance Stores in the Garrison of Quebec...," Office of Ordnance, Quebec, 30 Sept. 1804; Vol. 1707, p. 91, "Return of Ordnance and Ordnance Stores, in the Garrison of Quebec...," Office of Ordnance, Quebec, 17 Dec. 1812. These lists included round and oblong, and the full range of oblong from 13 to 4-2/5 inch.

91 RAI, Swanston, op. cit., p. 66; Spearman (1828), op. cit., p. 101. See also Majendie, *Ammunition*, op. cit., p. 69, n. 2, for a discussion of the evidence.

92 For Chambers see above. Smith, op. cit., p. 287; RAI, Adye (1766), op. cit., p. 89.

93 Smith, op. cit., p. 137.

94 Smith, op. cit., p. 287; RAI, Adye (1766), op. cit., p. 89; RAI, Walton, op. cit., unpaginated. Adye said that round carcasses with three and five holes were sanctioned in 1760; Smith included four holes; he also included tables of trials with 13-inch carcasses with four holes in 1773; it is possible that the four-hole carcass was not accepted until the 1770s, although Smith included it in his table of 1760. Walton wrote that the carcasses with three and five holes were no longer used, but other than the diameter he gave no other details of the round carcass with four holes.

95 Smith, op. cit., p. 51.

96 Montaine, op. cit., p. 92.

97 Adye (1801), op. cit., p. 52. Cf. section on shells.

98 Ibid. and (1813), p. 87.

99 RAI, Swanston, op. cit., p. 67; Spearman (1828), op. cit., p. 101; Griffiths (1840), op. cit., p. 78 and (1847), p. 87; Spearman (1844), op. cit., unpaginated; *Aide-Mémoire* (1852), op. cit., Vol. 3, p. 150.

100 Griffiths (1862), op. cit., p. 87; Miller, op. cit., p. 397; Majendie, *Ammunition*, op. cit., p. 327; Lefroy (1867), op. cit., p. 81; Owen (1873), op. cit., p. 526.

101 RAI, Royal Laboratory Dept., Plates, No. 20, approved 9 July 1860; Majendie, *Ammunition*, op. cit., p. 70.

102 Majendie, *Ammunition*, op. cit., p. 69, n.4.

103 RMC, Mould, op. cit., pp 63-65; RAI, Swanston, op. cit., p. 66; Spearman (1828), op. cit., p. 101; Griffiths (1847), op. cit., p. 87; *Aide-Mémoire* (1852), op. cit.,

Vol. 3, p. 150.

104 Griffiths (1839), op. cit., p. 70; Straith, *A Treatise on Fortifications* (1846), op. cit., p. 566 and (1852), p. 127; RMC, Noble (1849), op. cit., p. 362.

105 Majendie, *Ammunition*, op. cit., pp. 69-71. The pattern was approved 9 July 1860.

106 Adye (1813), op. cit., p. 86.

107 RMC, Mould, op. cit., p. 63; Spearman (1828), op. cit., p. 102; Griffiths (1840), op. cit., p. 79; Straith, *A Treatise on Fortifications* (1846), op. cit., p. 566; Miller, op. cit., p. 95; Majendie, *Ammunition*, op. cit., p. 72; Lefroy (1867), op. cit. p. 337.

108 RMC, Mould, op. cit., p. 63; Spearman (1844), op. cit., unpaginated; DND, Fitzhugh, op. cit., pp. 272-3; RMC, Noble, op. cit., pp. 360-2; *Aide-Mémoire* (1852), op. cit., Vol. 3, p. 150; Owen, *Elementary*, op. cit., p. 84; Owen, *Rough Notes*, op. cit., pp. 69-70; Majendie, *Ammunition*, op cit., pp. 72-3.

109 Majendie, *Ammunition*, op. cit., p. 7; O.F.G. Hogg, *Artillery: Its Origin, Heyday and Decline* [henceforth *Heyday*] (London: Hurst, 1970), p. 162; Hughes, *Smooth-Bore*, op. cit., pp. 16, 52.

110 Hughes, *Firepower*, op. cit., p. 35., RAI, Williamson, Collections, *circa* 1770, op. cit., p. 100. Williamson wrote: "all grape for field service should be in tin cases..." and then went on to describe various kinds of what was clearly case or canister shot. Cf. RAI, Glegg, op. cit., pp. 13-4; RAI, Adye (1766), op. cit., pp. 111-12.

111 Adye (1801), op. cit., p. 197.

112 RAI, Borgard, Artillery Tables 34, 35; Glegg, op. cit., pp. 18, 65-7.

113 Glegg's table was consistent, five kinds, but Borgard's varied from four to six.

114 RAI, Borgard, Artillery Tables 34, 35; RAI, Glegg, op. cit., pp. 65-7. Borgard specified that the sack was made of Holland duck for 24 and 18-pounders, canvas for 12-, 9- and 8- sic pounders, and Hessian for 6- and 5-1/4-pounders; Glegg mentioned only canvas. Borgard indicated red lead for painting the grapeshot; Glegg did not specify a colour.

115 Muller (1780), op. cit., Table XXVII, pp. 143, 200-1; Smith, op. cit., pp. 140-1.

116 RAI, Williamson, Collections, *circa* 1770, op. cit., pp. 100-1.

117 RAI, Walton, op. cit., unpaginated; RAI, Frazer, Laboratory Work, *circa* 1800, op. cit., p. 17.

118 RAI, Frazer, Laboratory Work, *circa* 1800, op. cit., p. 17.

119 Adye (1801), op. cit., p. 197.

120 RAI, Glegg, op. cit., pp. 15-16, 61.

121 Ibid., pp. 15-16.

122 RAI, Frazer, Work Notes, op. cit., pp. 91, 95.

123 DND, Fitzhugh, op. cit., pp. 269; RMC, Noble, op. cit., p. 353.

124 Griffiths (1840), op. cit., p. 92; RMC, Noble, op. cit., pp. 351-2.

125 Majendie, *Ammunition*, op. cit., p. 18 and fn. 3, 6.

126 Ibid., pp. 18-19.

127 Ibid., p. 19. For Douglas' opinion see fn. 5 which also contains Sir William Congreve's contrary views.

128 Ibid., p. 7. Hogg, *Heyday*, op. cit., p. 162 and Hughes, *Smooth-Bore*, op. cit., p. 53 agree with Majendie, but they do not cite their source, which probably was Majendie.

129 RAI, Swanston, notebook, op. cit., 1826, unpaginated; Spearman, (1844), op. cit., unpaginated.

130 Adye (1827), op. cit., p. 335; Straith, *A Treatise on Fortifications* (1846), op. cit., p. 736.

131 Majendie, *Ammunition*, op. cit., p. 324; Lefroy (1867), op. cit., p. 80. But see

Majendie, p. 18, fn. 8 and 9, for the thickness of the plates and the diameter of the spindle, dimensions which were at variance with those given on p. 324.

132 Miller, op. cit., p. 110; RAI, Fraser, op. cit., p. 27; Majendie, Ammunition, op. cit., p. 20.

133 War Office circular 10 (new series), 1244, 5 June, 1866, cited by Majendie, p. 18, fn. 4.

134 Hogg, Heyday, op. cit., p. 163.

135 Griffiths (1840), op. cit., p. 92, (1847), p. 100, (1859), p. 96 and (1862), p. 99; Miller, op. cit., p. 397; Majendie, Ammunition, op. cit., p. 323; Lefroy (1867), op. cit., p. 80.

136 Miller, op. cit., p. 397, said an iron handle; Majendie, op. cit., p. 323, and Lefroy (1867), op. cit., p. 80, said a rope handle.

137 Hogg, Heyday, op. cit., pp. 160-1; Hughes, Smooth-Bore Artillery, op. cit., pp. 52-3.

138 Majendie, Ammunition, op. cit., pp. 6-7; Hogg, Heyday, op. cit., pp. 160-1.

139 Blackmore, op. cit., pp. 242-4.

140 RAI, Glegg, op. cit., pp. 13-14; RAI, Adye (1766), op. cit., pp. 111-12.

141 RAI, Borgard, Artillery Tables, "General Charge of one Hundred of Matted-Shott Compleated, for the Undermentioned Nature of Cannon according to the Regulation, in 1718"; RAI, Williamson, Collection, op. cit., circa 1770, p. 100. See also Adye (1813), op. cit., p. 345, for making substitute case shot in emergencies, using cartridge paper, pitch and rosin, and musket balls.

142 RAI, Glegg, op. cit., pp. 13-14.

143 "Extract of a Proportion of Ordnance and Stores embarked on board Ship, reputedly used at the Siege of Louisbourg 1758-" cited in Adrian B. Caruana, British Artillery Ammunition 1780 [henceforth Ammunition] (Bloomfield: Museum Restoration Service, 1979), pp. 5-6; RAI, Adye (1766), op. cit., pp. 115-16.

144 RAI, "Artillery Experiments, 1770-1; 1773," op. cit., unpaginated.

145 Wilkinson-Latham, op. cit., p. 28; Smith, op. cit., p. 230.

146 RAI, Laboratory Notes, circa 1798, op. cit., unpaginated; RAI, Fraser, Laboratory Work, op. cit., pp. 18-21; RAI, untitled Notebook, circa 1800, pp. 16-17; Caruana, Ammunition, op. cit., pp. 15-17.

147 RAI, Laboratory Notes, circa 1798, op. cit., unpaginated; RAI, Fraser, Laboratory Work, op. cit., p. 22; RAI, Bogue, op. cit., unpaginated.

148 RAI, Swanston, Papers, "A Course of Laboratory Instruction for the Royal Regiment of Artillery 1826," p. 94.

149 Ibid., pp. 90-1; Spearman (1828), op. cit., p. 127-9.

150 Hogg, Heyday, op. cit., p. 161.

151 RMC, Mould, op. cit., p. 40.

152 RAI, Swanston, Papers, "A Course...," pp. 90-1; Spearman (1828), op. cit., pp. 127-9. See also RMC, Mould, op. cit., p. 40 for some minor variations.

153 Majendie, Ammunition, op. cit., p. 7; RAI, Swanston, Papers, "A Course...," op. cit., pp. 90-1; Spearman (1828), op. cit., pp. 127-9.

154 DND, Fitzhugh, op. cit., pp. 269-70.

155 Straith, A Treatise on Fortifications (1846), op. cit., p. 567.

156 Griffiths (1840), op. cit., p. 567 and (1847), op. cit., p. 100.

157 RAI, Denning, "Laboratory Course," op. cit., pp. 56-7; RMC, Noble, op. cit., pp. 355-7; DND, Fitzhugh, pp. 269-70. There are minor differences between the tables in the three notebooks, but they are essentially the same.

158 Griffiths, op. cit., p. 96.

159 Majendie, Ammunition, op. cit., pp. 7, 15-17.

160 RMC, Noble, op. cit., p. 354; Majendie, Ammunition, op. cit., p. 17.

161 Majendie, *Ammunition*, op. cit., p. 16, fn. 3.
162 Vivian Dering Majendie, "On the Validity of General Shrapnel's Claim to the Invention of Shells in which the true Principle of Shrapnel Fire was first Enunciated and Applied," *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 3 (1863), pp. 398-408.
163 Douglas (1860), op. cit., pp. 481-2; W.B. Gardner, "The Shrapnel of the Past," *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 5 (1867), pp. 388-9.
164 Majendie, *Ammunition*, op. cit., p. 44, n.2, citing *Ordnance Select Committee Report on Shrapnel Shell*, p. 34.
165 Hogg, *Heyday*, op cit., p. 179; Hughes, *Smooth-Bore*, op. cit., p. 56.
166 *DNB*, Vol. 52, p. 163.
167 Gardner, op. cit., p. 387.
168 Ibid., pp. 389-90.
169 Ibid., pp. 391-4, 402-3.
170 Ibid., pp. 400-422.
171 Ibid., pp. 393-4.
172 Colonel Pickering, "Memorandum on Shrapnel Shells...," *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 2 (1861), p. 22.
173 Gardner, op. cit., p. 421, Farrington to Williamson, Woolwich, 14 Sept. 1813.
174 RMC, Mould, op. cit., p. 326; Adye (1827), op. cit., p. 100.
175 Gardener, op. cit., p. 416; Vivian Dering Majendie, "Some Considerations Respecting the Practical Vallue of Shells of the Shrapnel Class," *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 4 (1865), p. 5, citing Gurwood's *Despatches*, Vol. 8, p. 659 and Vol. 9, p. 281.
176 Gardner, op. cit., p. 422.
177 Ibid., pp. 422-4.
178 Captain E.M. Boxer, "Memorandum on Shrapnel Shells," *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 2 (1861), pp. 27-32; Vivian Dering Majendie, "On the Causes which led to the Suppression of the Original Shrapnel Shell, and the Adoption of the Diaphragm pattern," *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 4 (1865), pp. 152-4.
179 Boxer, "Memorandum...," op. cit., pp. 29-31; Majendie, "On the Causes...," op. cit., pp. 154, 155-8.
180 Majendie, *Ammunition*, op. cit., p. 47, n. 7, citing a letter by Boxer, 27 Sept. 1853.
181 Ibid., pp. 47-51.
182 Boxer, "Memorandum...," op. cit., p. 32; Majendie, op. cit., p. 48.
183 Majendie, *Ammunition*, op. cit., pp. 51-5.
184 Ibid., p. 55. Calibres of lead balls: musket, .68 inch; carbine, .60 inch; pistol .556 inch; buck shot, .33 inch.
185 *Quarterly List of Charges*, 1 July 1864, No. 915, approved 29 June 1864.
186 Ibid., 1 Oct. 1864, No. 953, approved 27 Sept. 1864.

Fuzes

1 Majendie, *Ammunition*, op. cit., p.231.
2 Mountaine, op. cit. p. 89.
3 Henry William Lovett Hime, *The Origin of Artillery* (London: Longmans, Green, 1915), p. 211; Hogg, *Heyday*, op. cit., p. 186; Hughes, *Smooth-Bore*, op. cit., p. 60.
4 RAI, Adye (1766), op. cit., p. 175; RAI, Williamson, Collections, *circa* 1770, op. cit., p. 41; Muller, op. cit., p. 205; Smith, op. cit., p. 303.
5 RAI, Williamson, Collections, *circa* 1770, op. cit., p. 41.

6 RAI, Adye (1766), op. cit., pp. 120-1; Muller, op. cit., p. 204; Smith, op. cit., p. 38.

7 RAI, "Practice Book 1760," unpaginated.

8 Muller, op. cit., p. 204; Smith, op. cit., p. 138.

9 RAI, Adye (1766), op. cit., p. 175.

10 RAI, Glegg, op. cit., p. 148; RAI, Meridith, "Laboratory Notes, 1780," p. 1; RAI, Fraser, Work Notes, op. cit., pp. 73-4; Adye (1801), op. cit., p. 104, (1813), p. 185 and (1827), p. 172; Spearman (1844), op. cit., unpaginated; *Aide-Mémoire* (1850), op. cit., Vol. 2, p. 192 and (1852), op. cit., Vol. 3, p. 151; *Lefroy (1867)*, op. cit., p. 339. Spearman (1828), op. cit., p. 225; Griffiths (1839), op. cit., p. 72, (1840), p. 81 and (1847), p. 89 say 1 lb. 12 oz. of mealed powder, but this appears to be a typographical error.

11 Adye (1813), op. cit., p. 185 and (1827), p. 172.

12 RAI, Adye (1766), op. cit., pp. 120-1; RAI, Williamson, Collections, *circa* 1770, op. cit., pp. 39-41; Muller, op. cit., pp. 204-6; Smith, op. cit., p. 138.

13 RAI, Laboratory Notes, *circa* 1798, unpaginated; RAI, Fraser, Work Notes, op. cit., pp. 68-79; RAI, Swanston, Papers, "A Course of Laboratory Instructions for the Royal Regiment of Artillery. 1826," unpaginated.

14 Adye (1827), op. cit., p. 173; *Aide-Memoire* (1852), op. cit., Vol. 3, p. 151.

15 RAI, Frazer, "Practice I," Observations ..., 20 June 1804, pp. 247-8.

16 RMC, Noble, op. cit., pp. 338-9. Cf. also RMC, Mould, op. cit., pp. 22-4.

17 RMC, Noble, op. cit., p. 342.

18 RAI, Frazer, "Practice I," op. cit., Observations ..., 20 June 1804, pp. 247-8.

19 Majendie, *Ammunition*, op. cit., p. 235-8.

20 Ibid., pp. 250-4.

21 Ibid., p. 255-6.

22 Ibid., p. 255, n. 5.

23 Ibid., pp. 256-8.

24 Ibid., p. 258.

25 Ibid., p. 234, and fn. 6, 7.

26 Ibid., pp. 263-4; see also Appendix L, pp. 379-86, for a long discussion and refutation of these reasons.

27 DND, Fitzhugh, op. cit., pp. 265-6; RAI, Denning, "Laboratory Course," op. cit., p. 12.

28 RAI, Denning, "Laboratory Course, op. cit., p. 12.

29 Straith, *Plans* (1841), op. cit., p. 103.

30 Griffiths (1843), op. cit., p. 86.

31 Griffiths (1852), pp. 79-80; *Aide-Mémoire* (1852), op. cit., Vol. 3, p. 152; Boyd, op. cit ., p. 254.

32 Straith, *A Treatise on Fortifications* (1858), op. cit., pp. 153-4; RAI, Richardson, op. cit., unpaginated.

33 Majendie, *Ammunition*, op. cit., p. 239.

34 Ibid, pp. 258-61.

35 Ibid, pp. 262-3.

36 Ibid., p. 271.

37 Ibid., p. 272, citing War Office Circular 822, par. 725, 16 Jan. 1863.

38 Ibid., p. 243, fn. 4.

39 Ibid., p. 244.

40 Ibid., pp. 245, 248-9.

41 Ibid., pp. 245-6; RAI, Richardson, op. cit., unpaginated.

42 Majendie, *Ammunition*, op. cit., pp. 247-8.

43 Ibid., pp. 273-6; Owen, *Elementary*, op. cit., pp. 93-4; Owen, *Principles* (1873), op. cit., pp. 134-5.

44 Majendie, Ammunition, op. cit., pp. 277-8; Owen, Elementary, op. cit., pp. 94-5.

45 Majendie, Ammunition, op. cit., pp. 278-81; Owen, Elementary, op. cit., pp. 85-8.

46 Majendie, Ammunition, op. cit., pp. 264-6; Owen, Rough Notes, op. cit., pp. 83-4.

47 Majendie, Ammunition, op. cit., p. 267.

Ignition

1 Flax was occasionally mentioned as an alternative. RAI, Glegg, Notes on Artillery, op. cit., p. 154; Spearman (1844), op. cit., unpaginated, "Slow-Match, — Artillery."

2 RAI, Glegg, op. cit., p. 154. According to the OED, slack means small or refuse coal; perhaps slacks means wood ashes in this reference.

3 Smith, op. cit., p. 161.

4 RAI, James, op. cit., pp. 483-4.

5 Spearman (1828), op. cit., pp. 274-5; Griffiths (1839), p. 78; Spearman (1844), unpaginated, "Slow-Match, — Artillery." Only Spearman (1844) mentioned the lyes composition — 50 lb. of wood ashes and 25 of lime.

6 Aide-Mémoire (1852), op. cit., Vol. 3, p. 154; Griffiths (1862), op. cit., p. 94; Miller, op. cit., p. 102.

7 Majendie, Ammunition, op. cit., pp. 224-5. Hemp yarn, pure, Russian, 100 lb.; Ashes, wood, 1 bushel; water, 50 gallons.

8 Spearman (1828), op. cit., p. 275; Aide-Mémoire (1852), op. cit., Vol. 3, p. 154; Majendie, Ammunition, op. cit., p. 226.

9 Griffiths (1840), op. cit., p. 87; Miller, op. cit., p. 102. A bale of 1 cwt. measured 3 ft. by 1 1/2 ft. by 1 ft.

10 Miller, op. cit., p. 102; Majendie, op. cit., p. 226.

11 Owen, Elementary, op. cit., p. 101.

12 Majendie, Ammunition, op. cit., p. 224.

13 RAI, Glegg, op. cit., pp. 26, 45.

14 RAI, Adye (1766), op. cit., pp. 117-18; RAI, "Artillery Experiments, 1770-3," op. cit., unpaginated; Smith, op. cit., pp. 143, 161; RAI, Laboratory Notes, circa 1798, unpaginated; RAI, Fraser, Work Notes, op. cit., pp. 54-9; RAI, Fry, op. cit., circa 1800, unpaginated; Adye (1801), op. cit., p. 137; Adye (1813) op. cit., p. 236; RMC, Mould, op. cit., pp. 53-4; RAI, Swanston, Papers, "A Course...," op. cit., unpaginated; Spearman (1828), op. cit., p. 274; Griffiths (1839), op. cit., p. 77; Spearman (1844), op. cit., unpaginated, "Quick-Match."

15 RAI, Artillery Experiments, 1770-3, unpaginated; Smith, op. cit., pp. 161, 143.

16 Adapted from RAI, Laboratory Notes, circa 1798, unpaginated.

17 RAI, Swanston, Papers, "A Course...," op. cit., unpaginated.

18 Majendie, Ammunition, op. cit., p. 225; Owen, Elementary, op. cit., p. 101; Lefroy, (1867) op. cit., p. 339; Owen (1873), op. cit., p. 165. Miller, op. cit., p. 102, says it burns 1 ft. in 3 seconds.

19 Majendie, Ammunition, op. cit., p. 224, n. 2, says 1778, citing Sir Augustus Frazer's MS Laboratory Notes, p. 58, but my notes on Frazer's "Notes" say 1788; moreover RAI, Laboratory Notes, circa 1798, also says 1788.

20 RAI, Adye (1766), op. cit., pp. 116-17; RAI, Artillery Experiments, 1770-3, unpaginated; Smith, op. cit., p. 143; RAI, Fry, circa 1800, op. cit., unpaginated; Adye (1801), op. cit., p. 137 and Adye (1813), op. cit., p. 236.

21 Majendie, Ammunition, op. cit., pp. 188, 213.

22 OED, citing John Harris, Lexicon technicium, or an universal English dictionary of arts and sciences, 1704-10.

23 RAI, Glegg, op. cit., p. 45; RAI, Adye (1766), op. cit., p. 114; Smith, op. cit.,

p. 143.

24 RAI, Laboratory Notes, *circa* 1798, unpaginated; Adye (1801), op. cit., p. 176; Spearman (1828), op. cit., p. 332; Griffiths (1862), op. cit., p. 95; Majendie, op. cit., p. 213.

25 Smith, op. cit., pp. 143, 304; RAI, Adye (1766), op. cit., p. 114.

26 See note 24.

27 RAI, Adye (1766), op. cit., p. 114; RAI, Laboratory Notes, *circa* 1798, unpaginated; Majendie, op. cit., p. 213.

28 This description has been abstracted from a number of sources. Differences were minor. RAI, Laboratory Notes, *circa* 1798, unpaginated; RAI, Frazer, Work Notes, op. cit., pp. 61-7; RMC, Mould, op. cit., pp. 19-20; RAI, Swanston, Papers, "A Course...," unpaginated; RMC, Noble, op. cit., pp. 291-3; *Aide-Mémoire* (1852), op. cit., Vol. 3, p. 154; Majendie, *Ammunition*, op. cit., pp. 213-4.

29 RMC, Mould, op. cit., p. 19, said that the paper measured 24 in. by 18 in., but that it was cut into a square 18 in. by 18 in.; RMC, Noble, p. 291, gave the same large dimensions but said that one-third was cut off, the large section well pasted, and the one-third laid in the centre and also well pasted; the *Aide-Mémoire* does not give dimensions of the paper but repeated the latter method of treatment; Majendie, *Ammunition*, op. cit., p. 347, said portfire paper, presumably meaning 60 lb. paper, was 24 in. by 18 in. and 100 lb. paper was 29 in. by 22-1/2 in.

30 Spearman (1828), op. cit., p. 332, was the first source to indicate painting:

copperas (green vitriol)	4 oz.
oil, linseed, raw	3 pints
dry lamp black	1/2 oz.
white lead	12 lb.

Majendie, *Ammunition*, op. cit., p. 346, gave the formula for flesh colour:

lead, white, ground	10 lb.
lead, red, dry	4 oz.
shellac, gum	10 lb.
spirits, methylated	3 gal.

31 Majendie, *Ammunition*, op. cit., pp. 213-14.

32 Ibid., p. 189; Muller (1780), op. cit., pp. 203-4; Adye (1766), op.cit., p. 119; Smith, op. cit., p. 141. Padfield, op. cit., p. 102, refers to the battle of Quiberon Bay.

33 Muller (1780), op. cit., p. 203.

34 RAI, Laboratory Notes, *circa* 1797, unpaginated.

35 Majendie, *Ammunition*, op. cit., p. 190.

36 RAI, Frazer, Work Notes, op. cit., p. 58.

37 RAI, Laboratory Notes, *circa* 1797, unpaginated; RAI, Frazer, Work Notes, op. cit., pp. 22-32.

38 Majendie, *Ammunition*, op. cit., pp. 191-2; Douglas (1860), pp. 457-9.

39 RAI, Frazer, Work Notes, op. cit., pp. 22-30; RMC, Mould, op. cit., pp. 26-9; RAI, Swanston, Papers, "A Course...," pp. 30-5

40 RMC, Mould, op. cit., pp. 27-8; Majendie, *Ammunition*, op. cit., p. 209.

41 RMC, Mould, op. cit., pp. 28-9, says there were only six threads of worsted; Majendie, *Ammunition*, op. cit., pp. 192, 209-10.

42 Majendie, *Ammunition*, op. cit., pp. 193-4.

43 Ibid., p. 194.

44 Ibid., pp. 194-5, 198. Cf. DND, Fitzhugh, op. cit., p. 250; RMC, Noble, op. cit., pp. 312-14; *Aide-Mémoire* (1852), op. cit., Vol. 3, p. 163, where somewhat different proportions of ingredients are given for the detonating agent.

45 Majendie, Ammunition, op. cit., p. 196.

46 Ibid., pp. 196-7.

47 Straith, A Treatise on Fortifications (1858), op. cit., pp. 155-6; Owen, Rough Notes, op. cit., p. 91; Majendie, Ammunition, op. cit., pp. 204-5.

48 Majendie, Ammunition, op. cit., p. 205.

49 Ibid., pp. 206-7; Owen, Rough Notes, op. cit., pp. 91-2.

50 Pope, At 12 Mr. Byng was shot..., op. cit., p. 321, n. 18.

51 Douglas (1860), op. cit., pp. 457-9; Padfield, op. cit., p. 117, "Parts of a Gun Lock," reproduces a drawing of the individual parts, as well as the lock complete taken from H.M.S. Excellent.

52 Douglas (1820), op. cit., pp. 207-8.

53 Ibid., p. 209.

54 Ibid., pp. 206-9.

55 Douglas (1820), op. cit., p. 287, Crew to Douglas, 10 Sept. 1817.

56 Ibid., p. 288, Griffin to Douglas, 16 Jan. 1818.

57 Ibid., pp. 289-92, Dickson to Douglas, 20 April 1818.

58 Douglas (1860), op. cit., p. 461.

59 Majendie, Ammunition, op. cit., p. 192, n. 7.

60 Ibid., pp. 192-3.

61 Ibid., p. 194, n. 8.

62 Douglas (1860), op. cit., pp. 462-4.

Sights and Sighting

1 Owen, Elementary, op. cit. p. 170; Hogg, Heyday, op. cit.; p. 238.

2 Hogg, Heyday, op. cit., p. 239; Adye (1766), op. cit., p. 163-4;

3 Hogg, Heyday, op. cit., p. 240.

4 Muller (1780), op. cit., pp. 44-5.

5 Adye (1766), op. cit., pp. 162-4.

6 Hogg, Heyday, op. cit., p. 238; Adye (1766), op. cit., 162-3; Adrian B. Caruana, "On the Aiming of Artillery," The Canadian Journal: Arms Collecting, Vol. 18, No. 3 (Aug. 1980), p. 88; RAI, "Repository Course. For the Use of the Sergeant Instructors. Instructions in the Exercise and Management of Heavy Ordnance. Part 7. Article 11, Plate 5."

7 Encyclopaedia Britannica, 15th ed., Macropoedia, Vol. 8, p. 623.

8 Kaestlin, op. cit., p. 65, XXIV/73.

9 Adye (1766), op. cit., pp. 162-3; Muller (1768), op. cit., cited by Caruana, "Aiming," op. cit. p. 88.

10 RAI, "Repository Course..." op. cit.

11 Adye (1766), op. cit., pp. 163-4.

12 Miller, op. cit., pp. 232, 264, 343.

13 Straith, A Treatise on Fortifications (1846), op. cit., p. 600.

14 Owen, Elementary, op. cit., pp. 172-3., Howitzers had usually had a dispart sight cast on the muzzle; by an order dated 2 Nov. 1859, a dispart was to be added to all brass ordnance before issue. Miller, op. cit., p. 86; Owen and Porter, op. cit., p. 59.

15 "Abstract of Papers respecting the Military Society, Established at Woolwick, 1772-3-4-5," Minutes of Proceedings of the Royal Artillery Institution (Vol. I, 1958), p. xxx.

16 Parks, Lower Fort Garry NHP, brass 6-pdr., 1797; Carleton Martello Tower NHS, two brass 3-pdrs., 1799 and 1800. There is at Woolwich two brass 6-pdrs. dated 1778 that appear to have a block drilled for tangent scale; possibly these were experimental models.

17 Rotunda, Woolwick, 9-pdr. brass field gun on an original field carriage II/47a,

cast by Kinman in 1797. This gun has two holes drilled in the cascable which could well be to attach a tangent scale.

18 Adye (1801), op. cit., p. 201 and (1813), p. 372.

19 Landmann, *Principles*, op. cit., p. 37.

20 RAI, "Spherical Case Shot, Tangent Scales etc. & Service charge of Powder, No. 53," and RAI, James Nisbet Colquhoun Papers, Notebook, "Tables of Ranges &c of Spherl. Case Shot fired from Field Guns, with the Round Short Charge from Practice at Mount's Bay in Cornwall – 1813." The former includes drawings of the scales.

21 Adye (1801), op. cit., p. 201; Miller, op. cit., p. 85.

22 William Congreve, *A Description of Sights, or, Instruments for Pointing Guns...* (London: T. Egerton, 1819), p. 8; Douglas (1860), op. cit., p. 446; Owen, *Elementary...*, op. cit., p. 174.

23 DND, Fitzhugh, op. cit., pp. 118-121; RMC, Lloyd, op. cit., p. 170, 174-6; RAI, "Remarks on Sighting Ordnance," *circa* 1860, pp. 17-18; Owen, *Rough Notes*, op. cit., p. 28, plate 3, figs. 1, 2, 4, 5.

24 Miller, op. cit., p. 85; Owen, *Rough Notes*, op. cit. p. 29; Owen and Porter, op. cit., p. 61.

25 Unless otherwise noted this account is based on Sir William Congreve, *A Description of the Sights, or Instruments for Pointing Guns ...*, op. cit.

26 Cf. Douglas (1860), op. cit., p. 447. "The guns of the United States' frigates were fitted in a manner which enabled them to be fired horizontally, or at any required elevation. In some cases this was accomplished by the dispart, in others by tubes placed on the tops of guns, and either fixed parallel to the axis or provided with the means of being inclined to it so as to give to the gun the requisite degree of elevation."

27 Douglas (1860), op. cit., pp. 447-8; "Congreve Gun-Sights," *United Services Journal*, No. 28 (March 1831), pp. 393-4.

28 T.S. Beauchant, *The Naval Gunner* (Devonport and London, 1828), pp. 9-19.

29 Kaestlin, op. cit., p. 64, XXIV/55-6, "Two brass tangent scales for the 24-pr., of 9 feet." Unlike Beauchant's sights, which were secured by a spring, these were so constructed that they could be pinned transversely to the sight patch cast in front of the second reinforce ring.

30 Beauchant, op. cit., pp. 13-15.

31 Miller, op. cit., p. 86; RAI, "Remarks on Sighting Ordnance," *circa* 1860, p. 11.

32 Miller, op. cit., p. 86. He does not mention the 8-inch gun, but this must be an oversight since elsewhere he states that the 8-inch gun was issued with Millar's sights. See ibid., p. 291.

33 In 1881 it was described as half-round, but an earlier description and a drawing indicate that it was 2/3 of a circle. Owen and Porter, op. cit., p. 62; RAI, "Remarks on Sighting Ordnance," *circa* 1860, p. 9.

34 RMC, Noble, op. cit., pp. 160-3; Miller, op. cit., p. 86; RAI, "Remarks on Sighting Ordnance," *circa* 1860, pp. 9-11.

35 Miller, op. cit., p. 86; RAI, "Remarks on Sighting Ordnance," *circa* 1860, p. 11. The latter gives the date of introduction as 1846, Miller gives 1847. Capt. Wilford, R.A., "Remarks on Casemated Batteries in general, and their special application to Sea Defences; with some observations on the armament and service of Sea Batteries," (delivered 31 Dec. 1845), *Minutes of Proceedings of the Royal Artillery Institution*, Vol. I (1858), pp. 18-19.

36 Griffiths (1859), op. cit., p. 53; RMC, Lloyd, op. cit. pp. 172-3; Owen, *Elementary*, op. cit., p. 174; RAI, "Remarks on Sighting Ordnance," *circa* 1860, p. 19. For Maitland, see *DNB*, Vol. 35, pp. 376-7.

37 RMC, Noble, op. cit., p. 161; RMC, Lloyd, op. cit., p. 173; Griffiths (1859), op.

cit., pp. 52-3; Miller, op. cit., pp. 86-7; Owen, *Elementary*, p. 174, Plate 25, figs. 4 & 5; RAI, "Remarks on Sighting Ordnance," *Circa* 1860, pp. 12-13.

38 RMC, Noble, op. cit., p. 161; Douglas, op. cit., p. 448; RAI, "Remarks on Sighting Ordnance," *circa* 1860, p. 20; Owen, *Elementary*, op. cit., p. 174, fig. 6 opposite p. 174; Owen and Porter, op. cit., p. 63. The long scales were issued to the 10-inch gun of 86 cwt., the 8-inch guns of 60 and 75 cwt., the 68-pdr. of 95 cwt., the 32-pdrs. of 58 and 56 cwt.

39 RMC, Noble, op. cit., pp. 162-3; RMC, Lloyd, op. cit., pp. 173-4; RAI, "Remarks on Sighting Ordnance," *circa* 1860, pp. 20-22; Owen, *Elementary*, op. cit., pp. 174-5, Plate 25, figs. 8, 9.

40 Owen, *Elementary*, op. cit. 4, p. 173. The scales of field guns were vertical; those of howitzers, which slid down a groove similarly to field guns, were inclined at an angle of 85 degrees from the axis of the piece. RAI, "Remarks on Sighting Ordnance," *circa* 1860, pp. 13-14.

41 Owen, *Rough Notes*, op. cit., p. 30, Plate 3, fig. 8; RAI, "Remarks on Sighting Ordnance," *circa* 1860, pp. 29-30. It is not known when the radius board was adopted; both of these references are from the 1860s.

BIBLIOGRAPHY

Primary Sources and Repositories

Canada. Department of National Defence (DND). Library. Ottawa

Fitzhugh, H.T.
"A Course of Practical Artillery," Woolwich: 17 December 1845.

Moody, W.
"A Course of Practical Artillery," 1845.

Canada. National Archives (NA). Ottawa

RG8, I, Vols. 381, 384, 388, 395, 406, 416, 750, 982, 1664, 1706, 1707.

Fort Malden National Historic Park. Amherstburg, Ont.

Adye, R.W.
Notebook, circa 1800.

Great Britain. Public Record Office (PRO). London

Supply Department Records, Supp. 5, 76, "Notes on the Manufactures of the Royal Carriage Department," circa 1864.

WO33/7, "Report of the Committee on Ordnance," 26 July 1859.

Marcom Museum, C.F.B. Stadacona. Halifax

Proof Book, Woolwich, March 1800-June 1801. Untitled MS.

Nova Scotia. Public Archives. Halifax

MG12, Great Britain, Army. Miscellaneous — General, Vol. 4.

Royal Artillery Institution (RAI), Woolwich, U.K.

Adye, S.P.
"The Artillery Officer's Vade Mecum containing 1. The Dimensions of Guns Mortars & Howitzers, with those of their Carriages & Beds; also of other Carriages used in Artillery 2. Recipts for the different Laboratory Stores 3. The Ranges of Guns Mortars found by Experiments 4. Proportion of Stores Ammunition &c for different Services Vol: 1. New York 1766." (G3n/7)

"Artillery Experiments, 1770-1; 1773"
(G3g/10g).

"Artillery Implements for making: — Fuzes Lead Ball Gunpowder Portfires (Common) [Portfires] Coastguard Salt Petre"
circa 1826. (MD 1277).

"Artillery Practice & Stores"
circa 1780. (G3n/14)

Bogue, Richard
"Light 6 Pounder and Heavy Exercise." (G3n/33b)

Borgard, Albert
Artillery Tables, 1717-26

No. 30, "Particular Dimentions of all the Parts of an Iron 6 Pounder Cannon of Eight Foot Long According to the new Proportion given by Coll. Borgard in the year 1716." and "A Table for Surveying Iron Cannon in the Severall Parts According to the Regulation by Coll. Borgard in the year 1716."

No. 34, "Table of the Patern Grape-Shott, with their Nature and Number of Iron-Balls, Diameter of their Bottoms and Pinns; also the Length and Breadth of Canvas and Hessian, with the Length of Choacking Lines for Coating, and Boxes for Packing, with the Numer of Grapes, and total Weight Compleat when Boxed according to the New Regulation Calculated by Colonel Albert Borgard in 1717.

No. 35, "General Charge for one Thousand of Grape-Shott Compleated and Boxed, for the undermentioned Nature of Cannon according to the New Regulation by Col. Borgard 1718."

No. 36, "Dimensions, Weight and Value of Iron-Work for Hind & Fore Wheels for Travelling-Carriages; according to the New Regulation By Colonel Albert Borgard in the Year 1719."

No. 37, "Dimensions, Weight and Value of Iron-Work, for Hind and Fore Wheels for Travelling-Carriages; according to the New Regulation By Colonel Albert Brgard in 1719."

No. 38, "Dimentions, Weight and Value of Iron Work for Hind and Fore Extrees, for Travelling Carriages; according to the New Regulation by Colonel Albert Borgard in the Year 1719."

No. 39, "No. 1. Dimentions, Weight and Value of Iron Work for Bodies of Travelling Carriages according to the New Regulation in 1719."

No. 40, "No. 2. Dimentions, Weight, and Value of Iron Work for Bodies of Travelling Carriages according to the New Regulation in 1719."

No. 41, "No. 3. Dimentions, Weight, and Value of Iron Work for Bodies of Travelling Carriages according to the New Regulation in 1719."

"General Charge of one Hundred of Matted-Shott Compleated, for the Undermentioned Nature of Cannon according to the Regulation, in 1718.

-----. "Drawings of Venetian Artillery from the hand of Lieut-General Albert Borgard circa 1700. A.D." (G3f/30).
-----. "Practtis of Artillery," circa 1714. (G3f/43)

Caffin, William
Laboratory Notes, 1797. (G3n/24)

"Captain Shands Method of Pointing and Working Garrison Guns during the late Siege of Gibraltar"
(MD 91)

"Casting Proving Guns &c"
Circa 1775, Vol. 1 and 2. (G3d/45 and 45b)

Cockburn, John
"Notes on Artillery," Ms notebook, Woolwich, *circa* 1820. (G3n/296)

Cockburn, Robert
"Practical Course of Instruction," Woolwich, 1830. (G3n/29)

"Collected Military Papers"
Vol. 2. (MD 1080)

Colquhoun, James Nisbet
Papers, Notebook (MD 915/2-7)

Congreve, William
"Exercise and Manoeuvres for two Light six Pounders or two Heavy three Pounders of General Desagulier's Construction." (G3n/13)

Congreve, Major General and Colonel Sir William
Papers, 5 Boxes (MD 213)
  Box I, M.MS/226, "Report of Select Committee on Col. Congreve's new gun," Woolwich, 7 April 1814.
  M.MS/267, Farrington to Hutton, 19 April 1814.
  M.MS/268, Hutton to Mudge, 29 April and 8 June 1814.
  M.MS/269, Johnson to Farrington? , 26 May 1814.
  M.MS/270, report on experiments, 31 July 1815.
  M.MS/271, Farrington to Master General, 1 Aug. 1815.

"Defence of the Coast"
(G3n/77)

Denning, Sergt. A.
Papers, "Laboratory Course." (MD 1359)

"Equipment, Royal Arty. 1813-1819"
(MD 980)

"Experiment in Gunnery — carried on at Woolwich 1819 to 1826"
(G3g/6)

"Experiments Landguard Fort 1780"
(G3g/10d)

"Experiments with long and round Shot under the Direction of Genl. Williamson August 1774; Do. on Dr. Pollocks Shot and Shell by Capt. Tovey in 1776"
(G3g/10e)

"Experiments Woolwich 1778-9"
(G3g/10c)

Frazer, Augustus S.
"Laboratory Work" and "Work Notes." (G3n/28). Both these volumes, which are very

similar in content, have the same shelf number. The latest dated process in the first is 1795 and in the second 1803.
-----. "Practice," Vol. 1 (G3n/28a). Vol. 2 could not be located. This volume contains practice tables, 1810-11 on Sutton Heath, as well as copies of documents dating back to the 1740s.
-----. Papers, 1776-1835. (MD 860)

Fry, Oliver
"Tables of Ranges, Weights, &c. of Ordnance." (G3n/25)

"General Statement of the Regulation & Practice of the Inspector of Artillery's Dept. in Examining, Proving and Receiving of Iron Ordnance supplied by Contractors for H.M. Service and that of the East India Coy"
(MD 880)

Glegg, Samuel
Notes on Artillery, *circa* 1752 (G3n/6)

Greg, Edward Hyde
Drawings of guns, mortars, howitzer, etc. "Presented to the Royal Regiment of Artillery in 1948, by Colonel Alexander Greg, fourth Son of Edward Hyde Greg of Norcliffe Hall, Cheshire, who Executed the Drawings in 1848 and was later a Captain in the 4th Royal Lancashire Militia Light Infantry." (G3n/73)

"Instructions for practising the Modern method of Maneuvring & Quick-firing with Field pieces given to the four Regiments of Artillery in His most faithful Majestys Service under the inspection of Colonel F. Macbean, 1765"
(Pamphlets, Vol. 88/III). This is a handwritten MS, but it is bound into a series of printed pamphlets.

James, Thomas
"his Book of Artillery &c at the Office of Ordnce. in the Tower of London March the 25th, 1722." (G3n/1a)

Jeffrey, James
"Thoughts on Guns, Bullets and Bombs," 1787. (G3n/23)

Labratory Notes, *circa* 1798
(G3n/35)

Landmann, Isaac
"Gun Factory Notes 1793," 2 vols. (G3d/2 and 3)
-----. "Notes on Artillery." (G3n/37) This volume is made up of three distinct units: part 1 seems to be the incomplete draught of a book on sieges; part 2 gives tables of dimensions and the gun constructions of Armstrong, Blomefield, and Desaguliers; part 3 is entitled "An Essay on the Tactic of Artillery" which, while in English, appears to be by someone in the French service. The MS is attributed to Landmann, but it is unsigned.

Lefroy, J.H.
Papers, Miscellaneous, 3 vols. (MD 1101). Vol. I
W. Congreve. *Memoire on the Record of Naval Ordnance*, 18 Nov. 1823, and handwritten notes commenting thereon.

Augustus S. Frazer, "Memorandum on the Question of reducing Charges for Naval Ordnance," 25 April 1831.

Meridith, David
"Laboratory Notes, 1780." (G3n/17) "Deposited by David Meridith, Mattross, in the 2d Battalion of the Royal Regiment of Artillery; and ordered by Lord Viscount Townshend to be kept in the Royal Military Repository, for the Use of the Non-commissioned Officers of said Regiment, 28 Novem. 1780."

"Mem. of Colonel Millars 68 Pr. Gun of 10 Calibres & Cwt. 50.0.0," 1820-3
(G3n/80/7)

Lt.-Gen. Robert Morse, I.G.F., to John, Earl of Chatham, M.G.O., 19 July 1804
(MD 907)

Notebook, 1805-22
(G3n/80/8)

"A particular account of the Alterations made in the Light 6 Pr. Carriages in the Year 1776 by order of the Right Honourable Lord Visct. Townshend Master General of the Ordnance &ca. — also the reasons for making them"
(G3f/32)

A Portfolio of Drawings
Circa 1735.

"Practice Book 1760"
(G3g/10)

"Practice with Case Shot from Two Six Pounders of the new Construction against a Curtain 9 Feet high and 60 Feet Wide," Winchester, 30 Oct. 1780
(G3g/10f)

"Practice with Two Light Six Pounders of the New Construction"
(MD 1277), Winchester, 25 Sept. - 26 Oct. 1780.

"Remarks on Sighting Ordnance"
Circa 1860. (MD 920)

"Report of the Committee of Officers, Selected to take into consideration the several Artillery Equipments, with a view to make such alterations as might be deemed advisable, from the experience gained during the late War, as authorized by His Grace the Master General, under Date of the 3rd of December 1819
(MR/37)

"Report of a Select Committee convened 4th September 1820, to take into consideration the Observations of His Grace the Master General, on the Revision of the several Equipments in the Artillery Service."
(MR/37) The last two items were bound into the same volume.

Reports on Artillery 1854
(MR/51)
"Confidential Circular. Abstract of Recommendations and Observations taken

from a Report of a Committee of Officers of the Royal Artillery and Royal Engineers appointed by the Master General of the Ordnance to consider what might be the best Arrangements under ordinary Circumstances for Coast Batteries: Reported 5th November 1852, and approved by the Master General and Board 28th January 1853 M/612," Woolwich, 17 Feb. 1853.

"Confidential. Minutes of the Committee on Ordnance," Nov. 1857-Dec. 1858.

"Confidential. Papers submittd to the Committee on Ordnance, November 23, 1857, and printed by their direction."

"Confidential Circular," Horse Guards, 1 Jan. 1861 Report of a Committee of Ordnance to revise Confidential Circular of 1853. M/612, Woolwich, July 1860 .

"Repository Course. For the Use of the Sergeant Instructors. Instructions in the Exercise and Management of Heavy Ordnance. Part 7th. Article 11." (G3h/94)

"---. Part 7th, Article 17th. Gunpowder — its Proof and Reception — Eprouvettes." (MD 1277)

Richardson, J.B.S.
Account of the Long Course, Shoeburyness, 1859-60. (G3n/34).

Royal Carriage Department (RCD)
Plates. 1860s.
Royal Laboratory Department
Plates. 1860s.

Shone, T.A.
"Note Book of the late General T.A. Shone R.A." Presented by Mr. E. Morris, late Sergt. Major R.A. (G3n/67)

Shuttleworth Drawings, circa 1820

"Spherical Case Shot, Tangent Scales &c. & service charge of Powder, No. 53"
(MD 870)

"Store Returns 1758 & 1761. Art: Experiments 1776. I. A Proportion of Ordnance and Stores for Halifax in Nova Scotia with Distribution on Board (1758?); II. A Proportion of Brass Ordnance and Stores for a Batrtering Train agreeable to Mr. Secretary Pitt's letter of 20th Jany. 1761; III. Experiments in Artillery by Doctor Pollock in August 1776"
(G3n/16)

Strange, T.B.
"Notes on Artillery," 1851. (G3n/75a)
-----. "Drawings on Artillery," 1851. (G3n/75b)

Swanston, Master Gunner Robert
Papers, 1799-1872. "A Course of Laboratory Instructions for the Royal Regiment of Artillery 1826." (MD 756)

Trials, Goodwood, 1792
(G3g/10i)

Trials, Woolwich, 1774
(G3g/10h)

Untitled Notebook
Circa 1800. (G3n/62)

Walton, Thomas
"Gunnery Tables 1780-1792 in handwriting of Mr Thomas Walton." (G3n/35a)

Williamson, George
"Collections, Proportions & Experiments of Artillery," circa 1770. (G3n/3)

-----. "Manuscript Treatise on Artillery &c, communicated by the General to Captain Collier in 1771." (G3n/9)

Royal Canadian Military Institute (RCMI). Library. Toronto

Paul, Lieutenant Abram
Notebooks, MS. No. 4. Quebec 1801-2. 3 vols.

Royal Carriage Department. Plates, circa 1860-80.

Royal Military College (RMC), Massey Library. Kingston.

Lloyd, E.M.
"Notes on Artillery," 1859.

Mould, T.R.
"Observations on a Course of Instruction in Artillery," June 1825.

Noble, A.
"Notes on Practical Artillery," 1849.

Published Primary Sources

"Abstract of Papers respecting the Military Society, Established at Woolwich, 1772-3-4-5"
Minutes of Proceedings of the Royal Artillery Institution, Vol. I (1858), pp. xxiv-xxxii.

Adye, Ralph Willett
The Little Bombardier, and Pocket Gunner. London, Egerton, 1801.
---. The Bombardier and Picket Gunner. 7th and 8th ed., London, Egerton, 1813 and 1827.

Anderson, John
General Statement of the Past and Present Condition of the Several Manufacturing Branches of the War Department, as called for by a letter dated 8th May 1856. London, Eyre and Spottiswoode for Her Majesty's Stationery Office, 1857.

Beauchant, T.S.
The Naval Gunner. Devonport and London, 1828.

Boxer, E.M.
Treatise on Artillery, prepared for the use of the Practical Class, Royal Military Academy. Sect. 1 - Part 1. London, Eyre and Spottiswoode for Her Majesty's Stationery Office, 1859.
---. Diagrams of Guns referred to in Treatise on Artillery prepared for the use of the Royal Military Academy. Section 2. - Part II. London, Eyre and Spottiswoode for Her Majesty's Stationery Office, 1853.
---. "Memorandum on Shrapnel Shell." Minutes of Proceedings of the Royal Artillery Institution, Vol. 2 (1862), pp. 27-32.

Boyd, John M'Neill
A Manual for Naval Cadets. London, Longman, et al., 1857.

Briscoe, H.W.
"Relation of the Power to the Weight in the Various Machines, in General Use, for the Mounting, Moving, and Transporting, of the Heavy Ordnance, Carriages, and Platforms in the Service." Minutes of Proceedings of the Royal Artillery Institution, Vol. 4 (1865), pp. 271-6.

Burn, Lieutenant-Colonel
Questions and Answers on Artillery. 2nd ed. Woolwich, Jackson, n.d. circa 1860 .

Campbell, F.
"Effect of Shot and Shell upon Snow and Ice." Minutes of Proceedings of the Royal Artillery Institution, Vol. 1 (1858), pp. 54-62.

Clayton, E.
"On the principles which regulate the Efficiency of Artillery Projectiles." Minutes of Proceedings of the Royal Artililery Institution, Vol. 8 (1874), pp. 295-310.

Cleaveland, Samuel
Notes on the Early History of the Royal Regiment of Artillery. Woolwich, Royal Artillery Institution, n.d.

Clerk, H.
"On the Duration of Wooden Carriages in a Hot Climate." Minutes of Proceedings of the Royal Artillery Institution, Vol. 4 (1865), pp. 221-6.

Congress. Senate. (United States)
Military Commission to Europe in 1855 and 1856: Report of Major Alfred Mordecai of the Ordnance Department. Executive Document No. 60. Washington, D.C., Bowman, 1860.

Congreve, Sir William
A Description of the Sights, or, Instruments for Pointing Guns; proposed by Major General Sir William Congreve, Bart. for the Use of the Navy, and now adopted in that service. With an Account of the Practice made with them on board H.M.S. Liffey. 2nd ed. London, T. Egerton, 1819.
---. A Concise Account of the Origin & Principles of the New Class of 24-Pounder Medium Guns of Reduced Length and Weight... London, Egerton, [1820].

---. *An Elementary Treatise on the Mounting of Naval Ordnance*. London, Egerton, 1811. Reprint. Ottawa, Museum Restoration Service, 1970.
---. *Memoir on the Recoil of Naval Ordnance*. N.p., n.p., 1823.
---. *A Short Account of the Improvements in Gun-Powder made by Sir William Congreve, Comptroller of the Royal Laboratory: being the Substance of the Specification of a Patent granted to him the 3d of July, 1815*. London, Egerton, 1818.
---. *A Statement of Facts relative to the Savings Which have Arisen from Manufacturing Gunpowder at the Royal Powder Mills; and of the Improvements which have been made in its strength and durability since the year 1783*. London, Whiting, 1811.

"Congreve's Guns"
United Services Journal, No. 35 (Oct. 1831), pp. 390-1.

"Congreve's Gun-Sights"
United Services Journal, No. 28 (March 1831), pp. 393-4.

Dahlgren, J.A.
Shells and Shell-Guns. Philadelphia, King & Baird and London, Trübner & Co., 1857.

A Description of the New-Invented Gun called a Carronade; and its Uses
Pamphlet. Edinburgh, [1779].

Dixon, Captain Manley
"Remarks on Military Carriages and Gun Metal." *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 1 (1858), pp. 105-6.

Douglas, Sir Howard
A Treatise on Naval Gunnery. 5 editions. London; John Murray, 1820-60.

Fortune, T.
The Artillerist's Companion, containing the Discipline, Returns, Reports, Pay, Provision, &c. of that Corps, in Field, in Forts, at Sea, &c. London, Millan, 1778.

Fraser, G.H.
Notes on Matériel as at present Issued at the Royal Laboratory, Woolwich, for Smooth-Bore Guns, Small Arms, and Rifled Guns, Armstrong. London, Eyre and Spottiswoode for Her Majesty's Stationery Office, [1864].

Gardner, W.B.
"The Shrapnel of the Past." *Minutes of Proceedings of the Royal Artillery Institution*," Vol. 5 (1867), pp. 385-425.

Goodenough, Captain
Notes on Gunpowder, prepared for the use of the Gentleman [sic] Cadets of the Royal Military Academy. Woolwich, Jackson, 1865.

Great Britain. War Office.
Manual of Field Artillery Exercises. London, H.M.S.O., 1861.

Greener, William
Gunnery in 1858: Rifles, Cannon, and Sporting Arms; Principles of the Science of

Gunnery, and describing the Newest Improvements in Fire-Arms. London, Smith, Elder, 1858.
---. The Science of Gunnery as applied to the Use and Construction of Firearms. London, Longman, 1841.

Griffiths, F.A.
The Artillerist's Manual and British Soldier's Compendium. 9 editions. London, 1839-62.

Hastings, Frank Abney
Memoir on the Use of Shells, Hot Shot, and Carcass Shells, from Ship Artillery. London, James Ridgway, 1828.

James, Charles
An Universal Military Dictionary. London, Egerton, 1816.

Kemmis, W.
Treatise on Military Carriages and other Manufacturers of The Royal Carriage Deparment. London, H.M.S.O., 1874.

Knox, John
An Historical Journal of the Campaigns in North America for the Years 1757, 1758, 1759, and 1760. Ed. Arthur G. Doughty. Toronto, The Champlain Society, 1914. 2 vols.

Landmann, Isaac
The Principles of Artillery, reduced into Questions and Answers, for the Use of the Royal Military Academy at Woolwich. 2nd ed. London, Egerton, 1808.

Lefroy, J.H.
Handbook for Field Service. 4th ed. Woolwich, Boddy, 1867.
---. "No. 23 — Notes on the Establishments of the British Field Artillery since 1815, with the Report of the Committee of Revision of 1819, and other documents." Minutes of Proceedings of the Royal Artillery Institution, Vol. 1 (1858), pp. 164-274.
---. "Note on Mortar Practice." Minutes of Proceedings of the Royal Artillery Institution, Vol. 2 (1861), pp. 13-16.

Lendy, Captain
Treatise on Fortifications or, Lectures delivered to Officers reading for the Staff. London, Mitchell, 1862.

Leslie, Captain
Remarks on a New Pattern Limber and Ammunition Wagon, with Observations on Different Systems of Draught. Woolwich, Royal Artillery Institution, 1859.

Lewis, Colonel
"Report on the Application of Forts, Towers, and Batteries to Coast Defences and Harbours." Professional Papers of the Corps of Royal Engineers, Q Series, Vol. 7, pp. 1-9.

Lyons, J.
"Brief Notes on Siege Equipment." Minutes of Proceedings of the Royal Artillery Institution, Vol. 2 (1861), pp. 33-40.

Majendie, Vivian Dering
Ammunition: A Descriptive Treatise on the Different Projectiles, Charges, Fuzes, Rockets, &c., at Present in Use for Land and Sea Service, and on other War Stores Manufactured in the Royal Laboratory. Part I. Ammunition for Smooth-bore Ordnance. London, Eyre and Spottiswoode for Her Majesty's Stationery Office, 1867.
---. "On the Causes which led to the Suppression of the Original Shrapnel Shell, and the Adoption of the Diaphragm Pattern." *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 4 (1865), pp. 152-8.
---. "On the Validity of General Shrapnel's Claim to the Invention of Shells in which the true Principle of Shrapnel Fire was first Enunciated and Applied." *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 3 (1863), pp. 398-408.
---. "Some Considerations Respecting the Practical Value of Shells of the Shrapnel Class." *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 4 (1865), pp. 4-9.

***A Memoir on Subjects Connected with Artillery*.**
Paris, J. Smith, 1818.

Miller, Major
Equipment of Artillery. Forming Part II. of the Series relating to Army Equipments. London, Eyre and Spottiswoode for Her Majesty's Stationery Office [1864].

Mountaine, William
The Practical Sea-Gunner's Companion; or an Introduction to the Art of Gunnery... London, Mount, Page, 1781.

Muller, John
Treatise of Artillery. 3rd ed. London, Millan, 1780. Reprint. Ottawa, Museum Restoration Service, 1965.

Müller, William
The Elements of the Science of War; containing the Modern, Established, and Approved Principles of the Theory and Practice of the Military Sciences... London, Longman, et al., 1811. 3 vols.

Nelson, R.J.
Gun Carriages: An Aide Memoire to the Military Sciences, 1846. Ottawa, Museum Restoration Service, 1972.

Owen, Charles H.
Elementary Lectures on Artillery, prepared for the use of the Gentlemen Cadets of the Royal Military Academy. 4th ed. Woolwich, Royal Artillery Institution, 1865.
---. *Rough Notes on the Manufacture of Ordnance, Carriages, and Ammunition prepared for the use of the Gentlemen Cadets of the R.M. Academy*. Woolwich, Royal Artillery Institution, 1867.
---. *The Principles and Practice of Modern Artillery*. 2nd ed. London, John Murray, 1873.

Owen, John F., and Morton Porter
Treatise on the Construction and Manufacture of Ordnance in the British Service. Reprint. London, Eyre and Spottiswoode for Her Majesty's Stationery Office, 1881.

Quarterly List of Changes in Military Stores, from January 1860 to December 1867.
London, Eyre and Spottiswoode for Her Majesty's Stationery Office, 1860-8. 3 vols.

Pickering, Colonel
"Memorandum on Shrapnel Shells, drawn up by Colonel Pickering, Royal Artillery, for the Select Committee. *Minutes of Proceedings of the Royal Artillery Institution*, Vol. 2 (1861), pp. 21-5.

Rees, Abraham
The Cyclopaedia; or, Universal Dictionary of Arts, Sciences, and Literature. London, 1819. 39 vols.

Remarks on the Promotion of the Officers of the Corps of Artillery in the British Service, and on the Application of the Arm in the Field
London, Hunter, 1819.

"Reports on 13-Inch Sea Service Mortars"
Minutes of Proceedings of the Royal Artillery Institution, Vol. 1 (1858), p. 445.

Robins, Benjamin
New Principles of Gunnery. London, J. Nourse, 1742.

Royal Engineers
Aide-Mémoire to the Military Sciences. London, John Weale, 1846-52. 3 vols.
---. *Aide-Mémoire to the Military Sciences*. 2nd. ed. London, John Weale, 1853. Vol. I.

Rudyerd, C.W.
Course of Artillery at the Royal Military Academy as established by His Grace the Duke of Richmond Master General of His Majestys Ordnance &c. &c. &c., 1793. Ottawa, Museum Restoration Service, 1970.

Smith, George
An Universal Military Dictionary, a copious explanation of the Technical Terms... London, 1779. Reprint. Ottawa, Museum Restoration Service, 1969.

Spearman, J. Morton
The British Gunner. 1st and 3rd ed., London, Parker, Furnivall, and Parkes, 1828 and 1844.

Straith, Hector
Plans Illustrative of Capt. Straith's Treatise on Fortifications and Memoire on Artillery. 3rd ed. London, Allen & Co., [1841].
---. *Plates for Major Straith's Treatise on Fortification and Artillery*. London, Allen and Company, 1852.
---. *A Treatise on Fortifications*. 1st - 7th ed., London, Allen and Co., 1833-58.

"A Synoptical Table of the Deal Practice carried on in the Year 1839"
No. 15, presented, 31 July 1846. *Minutes of the Proceedings of the Royal Artillery Institution*, Vol. 1 (1858).

Tousard, Louis de
American Artillerist's Companion, or Elements of Artillery. Philadelphia, C. and A. Conrad, 1809. Reprint. New York, Greenwood Press, 1969.

Townsend, Captain
"Remarks on Sleigh Carriages in the service of Artillery," Minutes of Proceedings of the Royal Artillery Institution, Vol. 1 (1858), pp. 115-123.

Wilford, Capt.
"Remarks on Casemated Batteries in general, and their special applications to Sea Defences; with some observations on the armament and service of Sea Batteries," 31 Dec. 1845. Minutes of Proceedings of the Royal Artilery Institution, Vol. 1 (1858), pp. 12-20.

Wilkinson, Henry
Engines of War: or, Historical and Experimental Observations on Ancient and Modern Warlike Machines and Implements, including the Manufacture of Guns, Gunpowder, and Swords with Remarks on Bronze, Iron, Steel, &c. London, Longmans, 1841.

Secondary Sources

Ashton, Thomas Southcliffe
Iron and Steel in the Industrial Revolution. 3rd ed. Manchester, Manchester University Press, 1963.

Batchelor, John, and Ian Hogg
Artillery. New York, Charles Scribner's Sons, 1972.

Barnes, Leslie W.
Canada's Guns. Ottawa, National Museum of Man, 1979.

Blackmore, H.L.
The Armouries of the Tower of London: I Ordnance. London, Her Majesty's Stationery Office, 1976.

Brookes, Kenneth
Battle Thunder: the Story of Britain's Artillery. New York, Osprey, 1973.

Campbell, R.H.
The Carron Company. Edinburgh and London, Oliver and Boyd, 1961.

Carman, W.Y.
The History of Firearms from the Earliest Times to 1914. London, Routledge & Kegan Paul, 1955.

Caruana, Adrian B.
"Albert Borgard and British Artillery of 1675-1725." The Canadian Journal: Arms Collecting, Vol. 20, No. 3 (Aug. 1982), pp. 77-87.
---. "The Artillery Gin." The Canadian Journal: Arms Collecting, Vol. 17, No. 2 (May 1979), pp. 35-40.

---. "Artillery Sledges & Gun Sleighs in North America, 1778-1783." The Canadian Journal: Arms Collecting, Vol. 16, No. 1 (Feb. 1978), pp. 8-13.
---. British Artillery Ammunition, 1780. Bloomfield, Ont., Museum Restoration Service, 1979.
---. "British Artillery Design in the 18th Century." The Canadian Journal: Arms Collecting, Vol. 15, No. 2 (May, 1977), pp. 35-43.
---. "British Production of Brass Ordnance, 1780." The Canadian Journal: Arms Collecting, Vol. 16, No. 4 (Nov. 1978), pp. 107-18.
---. Grasshoppers and Butterflies: The Light 3-Pounders of Pattison and Townshend. Bloomfield, Ont., Museum Restoration Serivce, 1980.
---. "The Identification of British Muzzle Loading Artillery." The Canadian Journal: Arms Collecting, Vol. 21, No. 4 (Nov. 1983), pp. 131-7.
---. "The Introduction of the Block Trail Carriage." The Canadian Journal: Arms Collecting, Vol. 18, No. 1 (Feb. 1980), pp. 3-16.
---. "John Muller's Treatise on Artillery." The Canadian Journal: Arms Collecting, Vol. 19, No. 2 (May 1981), pp. 50-6.
---. The Light 6-Pdr. Battalion Gun of 1776. Bloomfield, Ont., Museum Restoration Service, 1977.
---. "On the Aiming of Artillery." The Canadian Journal: Arms Collecting. Vol. 18, No. 3 (Aug. 1980), pp. 86-94.
---. "The Short 32 Pr Iron." Unpublished report for the Halifax Defence Complex, Environment Canada — Parks.
---. "Sir Thomas Blomefield and the Blomefield System of Ordnance." The Canadian Journal: Arms Collecting, Vol. 21, No. 3 (Aug. 1983), pp. 95-100.
---. "The Identification of British Muzzle Landing Artillery, Part I, the Designers," Vol. 21, No. 4 (Nov. 1983), pp. 131-37.
---. "Iron Mortars in 1812," The Canadian Journal: Arms Collecting, Vol. 25, No. 4 (Nov. 1987), pp. 125-130.

Comparato, Frank E.
The Age of the Great Guns; Cannon Kings and Cannoneers who forged the Firepower of Artillery. Harrisburg, PA., Stackpole Company, 1965.

Chown, John D.
"The Gun Sleigh." The Canadian Journal of Arms Collecting, Vol. 4, No. 4 (Nov. 1966), pp. 150-2.
---. "The Gun Sleigh Additional Notes." The Canadian Journal of Arms Collecting, Vol. 9, No. 4 (Nov. 1971), pp. 135-7.

De Volpi, Charles P.
Nova Scotia; A Pictorial Record. Don Mills, Ont., Longman Canada Limited, 1974.
---. Québec. Toronto, Longman Canada Limited, 1971.

Diderot, Denis
Encyclopédie ou Dictionnaire raissoné des sciences, des arts et des métiers, par une société de gens de lettres. Paris, 1750-1780.

Duncan, Francis
History of the Royal Regiment of Artillery. London, John Murray, 1879.

Erwin, James Q.
"Notes on the Cohorn Mortar." Military Collector & Historian, Vol. 13, No. 2 (Summer 1971), pp. 35-42.

ffoulkes, Charles J.
Arms and Armaments: a historical survey of the weapons of the British Army. London, Harrap, 1945.
---. The Gun-Founders of England. Reprint of 1936 ed. London, Arms and Armour Press, 1969.

Gooding, S. James
An Introduction to British Artillery in North America. Ottawa, Museum Restoration Service, 1972.
---. "The Light 6-Pdr. of the Eighteenth Century." The Canadian Journal of Arms Collecting, Vol. 8, No. 1 (Aug. 1970), pp. 3-11.
---. "The Traversing Platform," The Canadian Journal of Arms Collecting, Vol. 4, No. 3 (Aug. 1966), p. 107.

Graves, Donald E.
"A Note on British Field Artillery Equipments of the War of 1812." The Canadian Journal: Arms Collecting, Vol. 20, No. 4 (Nov. 1982), pp. 127-9.

Hall, Alfred Rupert
Ballistics in the Seventeenth Century. A Study in the relation of science and war with reference principally to England. Cambridge, University Press, 1952.

Hamilton, H.
The English Brass and Copper Industries to 1800. London, Longmans, 1926.

Hime, Henry William Lovett
Gunpowder and Ammunition: their origin and progress. London, Longmans, 1904.
---. History of the Royal Regiment of Artillery 1815-1853. London, Longmans, Green, 1908.
---. The Origin of Artillery. London, Longmans, Green, 1915.

Hitsman, J. Mackay
The Incredible War of 1812. Toronto, University of Toronto Press, 1965.

Hogg, Ian, and John Batchelor
Naval Gun. Poole, Dorset, Blandford Press, 1978.

Hogg, Oliver F.G.
Artillery: Its Origin, Heyday and Decline. London, Hurst, 1970.
---. English Artillery, 1326-1716. London, Royal Artillery Institution, 1963.
---. The Royal Arsenal: its background, origin, and subsequent history. London, Oxford University Press, 1963. 2 vols.

Hughes, B.P.
British Smooth-Bore Artillery: the muzzle-loading artillery of the 18th and 19th centuries. London, Arms and Armour Press, 1969.
---. Firepower: Weapons Effectiveness on the Battlefield, 1630-1850. London, Arms and Armour Press, 1974.

Jackson, M.H., and Carel de Beer
Eighteenth Century Gunfounding: the Verbrüggens at the Royal Brass Foundry, a chapter in the history of technology. Washington, Smithsonian Institute Press, 1974.

Jenkins, Rhys
"Early Gunfounding in England and Wales." Transactions of the Newcomen Society, Vol. 44 (1971), pp. 145-52.
---. "The Rise and Fall of the Sussex Iron Industry." Transactions of the Newcomen Society, Vol. I (1920), pp. 16-33.

Jobé, Joseph
Guns: an Illustrated History of Artillery. Greenwich, Conn., New York Graphic Society, 1971.

Kaestlin, J.P.
Catalogue of the Museum of Artillery in the Rotunda at Woolwich; Part I, Ordnance. Revised ed. N.p., n.p., 1970.

Lloyd, E.W., and A.G. Hadcock
Artillery: its progress and present position. Portsmouth, Griffin, 1893.

Manucy, Albert
Artillery through the Ages. Reprint of 1949 ed. Washington, U.S. GPO, 1956.

Mockridge, A.H.
"The Proving of Ordnance and Propellants," The Journal of the Royal Artillery, Vol. 77, No. 1 (1950), pp. 82-96.

Noble, Sir Andrew
Artillery and Explosives; Essays and Lectures Written and Delivered at Various Times. London, John Murray, 1906.

Padfield, Peter
Guns at Sea. London, Hugh Evelyn, 1973.

Parr, J.G.
Man, Metals, and Modern Magic. Cleveland, American Society for Metals, 1958.

Partington, J.R.
A History of Greek Fire and Gunpowder. Cambridge, W. Heffer, 1960.

Peterson, Harold Leslie
Round Shot and Rammers. Harrisburg, PA., Stackpole Books, 1969.

Pollard, H.B.C.
A History of Firearms. London, Bles, 1926.

Pope, Dudley
Guns. London, New York, Sydney, Toronto, Spring Books, 1969. (Originally published London, Weidenfeld and Nicolson, 1965.)
---. At 12 Mr. Byng was shot... London, Weidenfeld and Nicolson, 1962.

Raistrick, A.
Dynasty of Iron Founders. London, Longmans, 1953.

Robertson, Frederick Leslie
The Evolution of Naval Armament. Reprint of 1921 ed. London, Harold T. Storey, 1968.

Rogers, H.C.B.
Artillery through the Ages. London, Seeley Service, 1971.

Saunders, Ivan J.
"A History of Martello Towers in the Defence of British North America, 1796-1871." Canadian Historic Sites: Occasional Papers in Archaeology and History. No. 15 (1976), pp. 1-169. Ottawa.

Schubert, H.R.
"The First Cast-Iron Canon made in England." Journal of the Iron and Steel Institute, Vol. 146, No. 2 (1942), pp. 131-40.
---. History of the British Iron and Steel Industry from ca. 450 B.C. to 1775 A.D. London, Routledge & Kegan Paul, 1957.

Simmons, W.H.
"A Short History of the Royal Gunpowder Factory at Waltham Abbey." Controllerate of Royal Ordnance Factories, n.p., n.d. 1963 . Typescript. (RAI)

Sutcliffe, Sheila
Martello Towers. Newton Abbot, Devon, David & Charles, 1972.

Straker, Ernest
Wealden Iron. Reprint of 1931 ed. Newton Abbot, Devon., David and Charles, 1969.

Tucker, Spencer C.
"The Carronade." U.S. Naval Institute Proceedings, Vol. 99, No. 8 (August 1973), pp. 65-70.

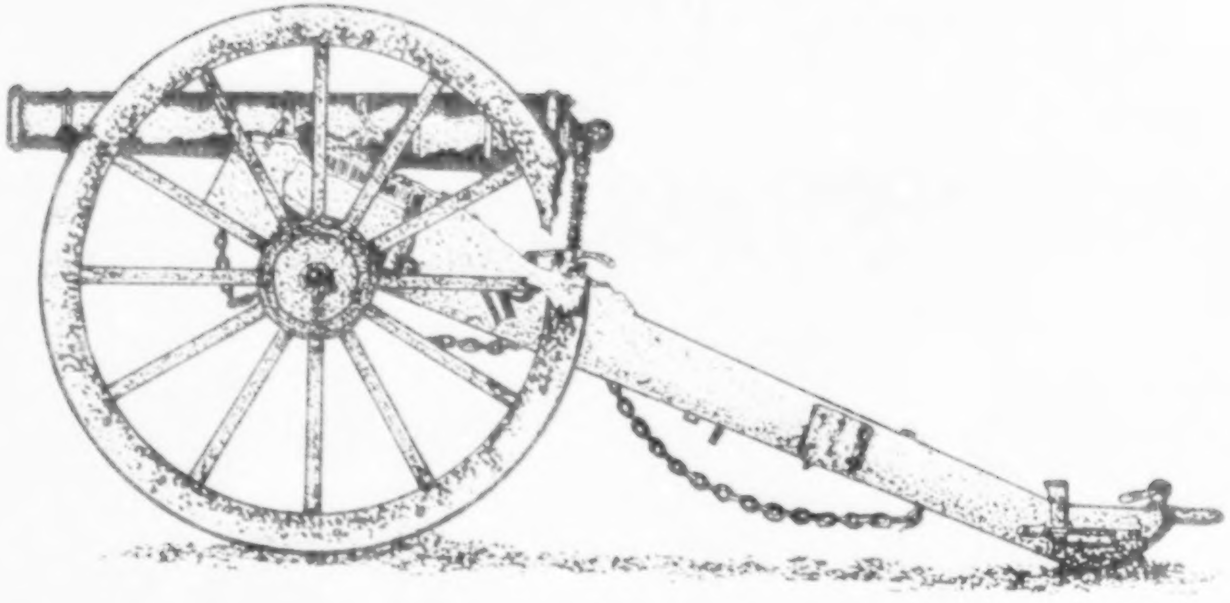
Weller, Jac
"The Artillery of the American Revolution," Military Collector & Historian, Vol. 8, No. 3 (Fall 1956), pp. 61-5; Vol. 8, No. 4 (Winter 1956), pp. 97-101; Vol. 9, No. 1 (Spring 1957), pp. 20-1; Vol. 9, No. 2 (Summer 1957), p. 51.

Wilkinson-Latham, Robert
British Artillery on Land and Sea, 1790-1820. Newton Abbot, Devon, David &Charles, 1973.

Wilson, A.W.
The Story of theGun. 3rd. ed. Woolwich, Royal Artillery Institution, 1968.

Wilson, Paul N.
"The Gunpowder Mills of Westmorland and Furness." Transactions of the Newcomen Society, Vol. 36, (1963-4), pp. 47-65.

This resource manual on the technology of British ordnance *circa* 1710 to the 1860s covers the production of ordnance, the history of the development and design of various pieces (guns, mortars, howitzers, carronades), their carriages and platforms, and the development of gunpowder, cartridges, fuzes, and projectiles.



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